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STANFORD UNIVERSITY, CALIFORNIA *

By SAMUEL B. MORRIS

Dean of the School of Engineering

Stanford University, young among the universities of America, celebrates in 1941 its fiftieth year as an institution of higher education. Training in the several branches of engineering began with the opening of the university in the fall of 1891 and engineering has continued as one of the major professional schools.

The first students found a small group of unfinished buildings erected in a wheat field on a part of the Palo Alto Stock Farm where the founder, Governor Leland Stanford, bred his famed strain of California racing horses. The Leland Stanford Junior University was endowed as a memorial to the Stanfords' only child, Leland Jr., who died in Italy at the age of sixteen. Today, after fifty years of gradual growth and not without struggle, the university has expanded until it comprises an important modern educational plant and a student body of some 4,400, representing forty-five states and twenty foreign countries. About one fourth are women, and the number of graduate students is about 1,200.

First president of Stanford University was the famed Dr. David Starr Jordan. Among the members of the first graduating class was Herbert Hoover, the university's most noted engineer, alumnus, and campus resident. The following year Ray Lyman Wilbur, president of Stanford since 1916, was graduated. Emerging from the financial struggle and years of litigation in the nineties, the university suffered severely from the earthquake of 1906, which cost several millions for restoration of damaged and demolished buildings and for making the structures resistant to future earthquake shocks. These periods of hardship were survived only through great sacrifices on the part of the faculty and the Stanford family.

Ever since the university was founded in 1885 the campus has been almost continually the scene of building construction. The current addition to the university skyline is the 250-foot monumental shaft that is being erected of steel and concrete to house the Hoover Library on War, Revolution, and Peace.

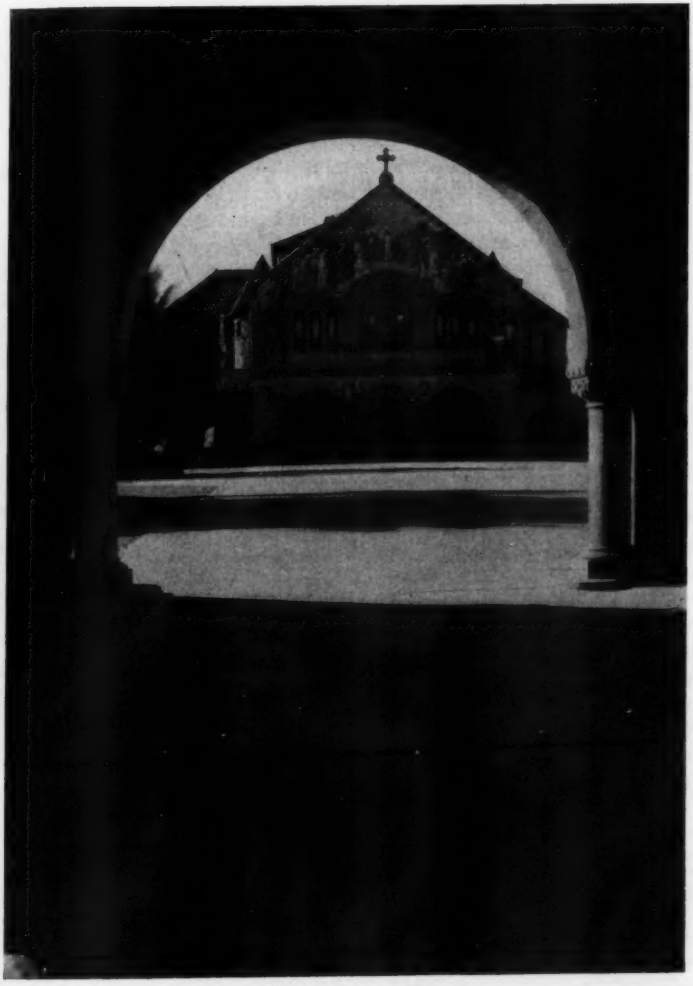
* The Wednesday afternoon, June 26, session of the 48th annual meeting, S. P. E. E., will be at Stanford University.

Stanford University is situated thirty miles down the peninsula southeast of San Francisco, in the beautiful Santa Clara valley and about three miles west of the shores of San Francisco Bay. The "Farm," as it is affectionately known, comprises about 9,000 acres of land which slopes gently to the rolling foothills, where fraternities, sororities, and many faculty families live on lands leased from the university. Some 1,500 acres of relatively flat land have been set aside as the campus proper, where the major part of the university program, including engineering instruction, is carried on. The advanced and clinical work in medicine, however, is conducted

ENGINEERING CORNER

in San Francisco, and some work in the biological sciences is carried on at the Hopkins Marine Station in Pacific Grove.

The main quadrangle of campus buildings is approached by way of Palm Drive, a mile-long avenue leading from the Southern Pacific Depot in the city of Palo Alto (population 19,000). The visitor first glimpses the low, buff sandstone buildings with their red-tiled roofs, from which emerges at the center the brilliantly colored mosaic façade of the Memorial Church, framed against the rising foothills and the Santa Cruz mountain range beyond. The beauty of the Church and the harmonies of its organ are prominent in the memories of all who have visited Stanford.



STANFORD MEMORIAL CHURCH

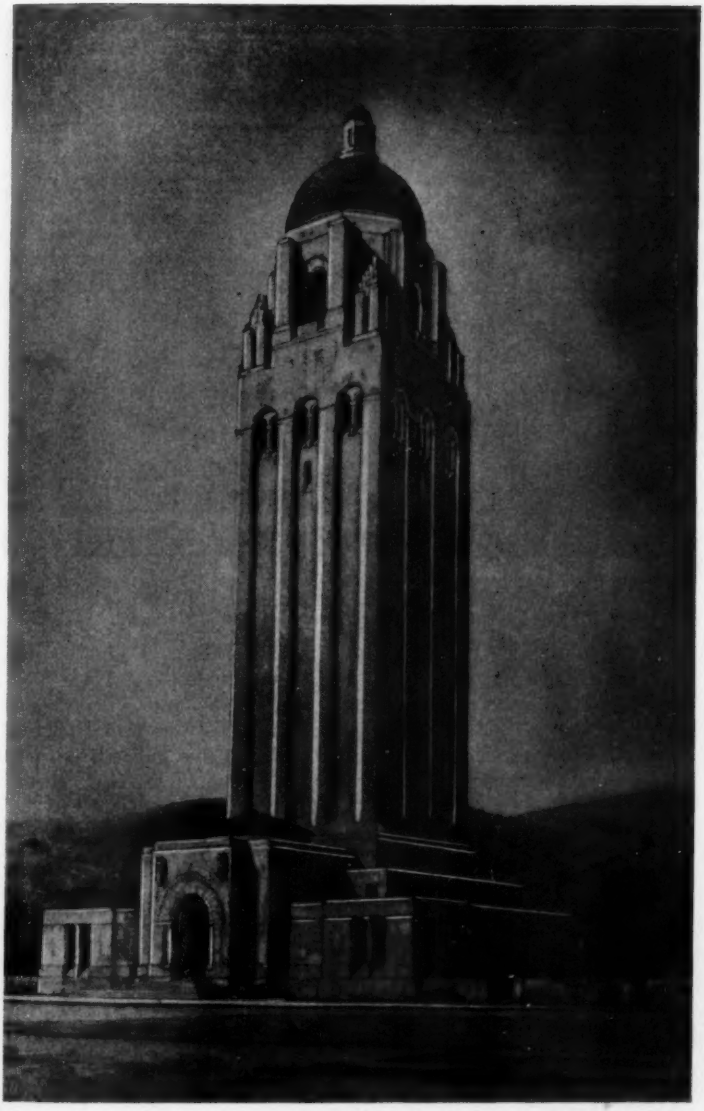
In addition to the classrooms and offices and laboratories to be found along the arched colonnades of the Main Quadrangle, there are many other buildings scattered about the campus. These depart somewhat from the style of the "Quad," but preserve a modified Spanish Mission influence. They include the University Library of 740,000 volumes; Memorial Hall with its modern theater plant; the Laurence Frost Amphitheater, a grassy sylvan bowl that seats 8,000 people at commencement time; the School of Education; and the Thomas Welton Stanford Art Gallery—all dominated by the Hoover Library now under construction. Along the full length of the south side of the Quad are engineering laboratory buildings. Other structures of note are the Museum, Chemistry Building, and men's and women's gymnasiums. Athletic fields are of unusual number and size, and include the giant football and track stadium, a polo field, and a famous golf course in the wooded foothills.

The founding grant provided for "a university of high degree." Accordingly, selection of candidates for entrance to the Lower Division of the university is made on the basis of superior fitness, taking into account scholarship, personal qualifications, and score on the college aptitude test. Each autumn the numbers of matriculants are limited to 450 men and 250 women.

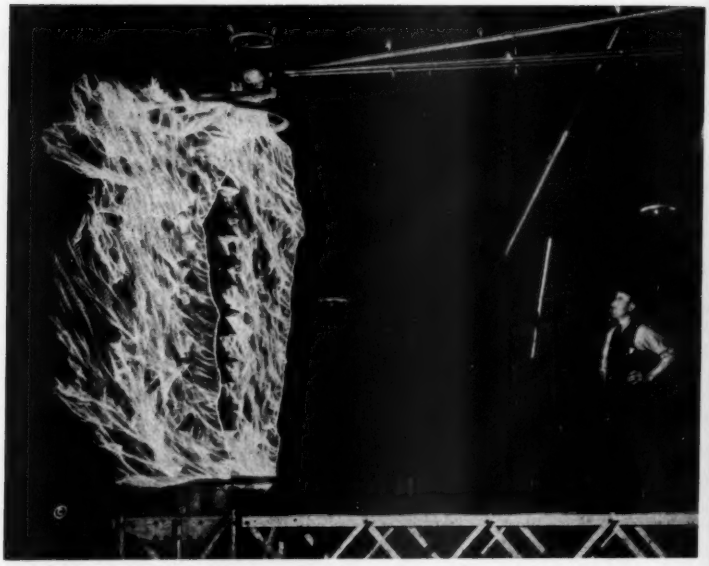
All students, including engineering students, are required in their first two years to take a broad training which includes written and oral English, foreign languages, history, social science, and biology. The engineering students are further required to take a broad training in mathematics, chemistry and physics, and the common core of engineering fundamentals upon which they may build any specialized training they wish. Stanford is opposed to specialized engineering training that lacks a broad foundation in the fundamentals common to all fields of engineering. Sufficient options, however, are provided by the School of Engineering by which a student may secure the added specialization he desires through careful planning of the four-year undergraduate program leading to the degree of Bachelor of Arts in Engineering.

The first graduate degree is that of Engineer in Civil Engineering, Engineer in Electrical Engineering, etc. This program in one of the various graduate departments gives the student time to carry on advanced study and prepare a thesis based upon sound research. He may, if he wishes, combine graduate work in engineering with courses in the Graduate School of Business. A limited number of students each year become candidates for the degree of Doctor of Philosophy.

The engineering laboratories at Stanford, occupying 72,000 square feet of floor space, include the following: Materials Testing; Cement and Concrete; Hydraulic; Vibration; Heat-Power; Automo-



HOOVER LIBRARY OF WAR, REVOLUTION AND PEACE. Now under construction.



An 830,000 volt sustained arc-over on the Hoover Dam disconnect switch tested at the two million volt Ryan High Voltage Laboratory.

tive; Aerodynamic; Forge, Foundry, and Machine; Gage Testing; Electrical Machinery; Illumination; Communications; High Voltage (2,000,000 volts); Metallurgy; Petroleum; and Military Science and Tactics. Members of the S. P. E. E. who visit Stanford University on the afternoon of Wednesday, June 26, will have an opportunity to inspect any laboratory in which they have a special interest.

WHITHER TECHNICAL INSTITUTES?

By PARK R. KOLBE

President, Drexel Institute of Technology

In the JOURNAL OF ENGINEERING EDUCATION for October, 1935, there appeared an article by the present writer under the same heading. It dealt with the fact that technical institutes—or non-degree programs, are universally welcomed as representing a necessary part of engineering education, while the graduates of these courses are denied any recognition by the arbiters of engineering destiny, namely the civil service commissions, the state licensing boards for engineers, or the Engineers' Council for Professional Development. The present article may perhaps be regarded as describing chapter two in the struggle for such recognition.

On February ninth there were assembled at the University Club in Pittsburgh representatives of the following institutions, who had responded to a call issued for the purpose of considering the claims of the technical institute for a recognized place in the field of engineering education:

University of Akron
Armour Institute of Technology *
Drexel Institute of Technology
Fenn College *
Franklin Union Technical Institute
Ohio Mechanics Institute
Pennsylvania State College
Pratt Institute
Rutgers University *
Temple University
University of Omaha
Wayne University
Wentworth Institute
Wyomissing Polytechnic Institute

There were also present:

Dr. F. L. Bishop, Secretary of the Society for the Promotion of Engineering Education
Dean A. A. Potter, Purdue University

* These institutions did not join in the petition to E. C. P. D.

Dean H. P. Hammond, Pennsylvania State College
President R. E. Doherty, Carnegie Institute of Technology

As a result of this meeting two actions were taken:

1. It was unanimously voted to send to the Secretary of the Society for the Promotion of Engineering Education a request that the Society establish, as part of its organization, a division to include technical institutes and other institutions offering non-degree engineering programs.

2. Eleven of the institutions represented at the Pittsburgh meeting subsequently signed and sent the following petition to the Engineers' Council for Professional Development:

> For many years leading authorities of the world of engineering education have emphasized the importance of the non-degree or technical institute engineering program. They have encouraged the establishment of these schools as filling a definite need for men of a training shorter and less theoretical than that given in the degree-granting engineering college. At the same time, nothing has ever been done to recognize, accredit, or legitimize the certificate granted by this type of institution. As a result, the graduates of these schools have found themselves, in many cases, at a definite disadvantage, since the training which they have secured receives little or no recognition from the engineering profession, as well as from many industrial employers who are naturally in doubt as to the meaning of the non-degree certificate. The representatives of the institutions here assembled do therefore petition the Engineers' Council for Professional Development, through its Committee on Engineering Schools, or such other appropriate committee as it may appoint, to institute a study of the non-degree programs, both day and evening, now existing in this country, and to devise and propose such a plan of recognition or accrediting as may seem wise and just.

Whatever the outcome may be, the Pittsburgh meeting, which was necessarily limited to a few selected institutions, will undoubtedly have considerable significance for all schools of the technical institute type. For the first time the engineering world, both professional and educational, has been asked to give serious consideration to legitimizing the non-degree, technical program, by surveying the highly diversified field of these offerings in the United States, and by proposing some plan for their classification and recognition. Thousands of technical institute graduates throughout the country will eagerly await the verdict. Are the certificates which they hold legal tender or merely counterfeit money?

ADVANTAGES OF NAVAL ACADEMY INSTRUCTION*

By EARL WENTWORTH THOMSON

Professor, U. S. N. A.

The United States Naval Academy has been in the paradoxical position of being one of the most looked-up to schools in the country, and at the same time being one of the most severely criticized. Is this not an appropriate time to examine some of the advantages and benefits of Naval Academy instruction from the viewpoint of midshipmen, instructors, naval officers and citizens?

Definite Objective and Mission

Much of the criticism has been based upon a misconception of the purpose, the objective and the mission of the Naval Academy. This institution is not a liberal arts college, it is not an engineering school, it is not a university. It exists only for the purpose of training midshipmen in the fundamentals of the naval profession, so that upon graduation they may be given commissions as Ensigns in the United States Navy, and will be qualified to accept the responsibilities therewith. The advantages of a fixed objective should be apparent to those of you who are training pre-medicals, pre-lawyers, pre-preachers, and pre-business men. This allows a definite course of instruction, pointed toward one goal, consolidated and coördinated with one idea. The midshipman has a job, that of training to become a naval officer, and he has a position promised him upon graduation if he meets quite exacting requirements. We do not have the disadvantages of students who have to spend hours in working outside of the college to secure money enough with which to pay their tuition, nor do we have the indecisiveness of indefinite objectives.

Definite Course of Instruction

Because of this definite purpose there has grown up at the Academy a fixed course of instruction, devoid of any electives, except in exceptional cases. The curriculum must meet the needs of the Navy, and if it trains the individual for employment in civilian pursuits, or if it meets his own individual desires, that is incidental.

* Presented at the 47th Annual Meeting, S. P. E. E. (Physics), Pennsylvania State College, June 19–23, 1939.

First, there must be developed a sense of the principles of leadership, a high sense of responsibility, and individual characteristics of alertness, loyalty, honor, initiative, dependability and reliability. Upon this is then based a knowledge of Seamanship, Navigation, Ordnance and Gunnery; an understanding of the fundamentals of various branches of engineering; and a foundation in mathematics, physics, chemistry, and the humanities. Experts in special fields cannot be developed, the post-graduate schools will turn out the engineers, the constructors, the designers of ships, of engines, of airplanes, and of communication systems.

Changes are now being made in the Naval Academy curriculum, based upon a recent report by Capt. W. W. Smith, who interviewed many of you before making his recommendations. These changes point to a greater emphasis on professional subjects, a concentration on fundamentals rather than on applications, a minimizing of memorization in recitations and on examinations, and a better correlation of departments. In our course in sophomore physics we have just eliminated about 25 per cent of the content, that which included the gyroscope, the physics of aviation, sub-aqueous sound detection, and naval optical instruments. We shall now have the same time as previously to teach fundamentals, if those bug-bears of a physics teacher can be pinned down long enough to recognize and classify.

The time assignment and the work load for every midshipman and every instructor, with the detailed content of every course, is fixed well in advance of the opening of the academic year. The schedule for the year 1939–40 was published to the various departments on June 1st, and when the midshipmen return from the summer cruise they will be given printed assignment sheets with definite pages in the textbooks, definite problems to work, and definite lessons to study for each examination. Together with this will be given the schedule of lecture and laboratory periods, so that any man will know on the first day of the course what he is going to do in any hour of the whole academic year. Barring visits from royalty, high-ranking politicians and naval officers, this schedule is established and invariant.

Methods of Instruction

The daily recitation is the backbone of all the instruction at the Naval Academy. The midshipman, either the night before or in alternate study periods, goes over the material of the daily assignment and comes prepared to recite either orally, at the boards, or in written quizzes, and be given his daily mark. In the sixty minutes of assigned time for a recitation, ten minutes is used up in marching over from Bancroft Hall, the dormitory, twenty-five min-

utes is consumed in answering questions, explaining difficult points, and emphasizing important paragraphs, and twenty-five minutes is required for the daily quiz. It is true that the securing of the daily mark uses up time that might be used for instruction, but it checks up that the midshipman actually is doing his work every day, as he will be required to do as a junior officer of the fleet. The misfit who cannot discipline his mind and actions to the study habit is found wanting and speedily "bilged." The Naval Academy cannot countenance the leisurely habits found at many colleges, where lectures are absorbed without much previous preparation on the part of the student, and where the examination, which can be crammed or tutored for overnight, determines the semester grade.

The alert mental attitude is fostered by small sections, of from twelve to sixteen men, in which the instructor can secure a response daily from each student. The midshipman must study daily, and must study hard, because lessons are long, there is much material to be covered, and the competition is stiff. The midshipmen laughingly tell of the plebe in a "savvy" section who dropped his chalk, and before he found it in the fog kicked up by the two "savoirs" on either side, had been skidded to a "wooden" section; such is our reputation for speed, pressure and accuracy.

Many men who have spent one or two years in colleges from all sections of the country, receive appointments and come to the Naval Academy. The percentage of these college men who fail is astonishingly high. Evidently they miss the leisure of the lecture system, and find it difficult to adapt themselves to a system where the student does the work of study and the process of mental digestion, instead of the professor. In the present third class of 480 men, of the 47 star men who secured averages of over 85 per cent, 17 entered the Academy via college certificate, 16 by substantiating examinations, in mathematics and English, after an accredited high-school course, and 14 by the six regular examinations in Algebra, Geometry, Physics, Ancient and United States History, and English. This shows that previous college training is not of great advantage.

Other methods of instruction are in use in addition to the daily lesson. In the physics course in which I write the daily lesson sheets, do the major part of the lecturing, outline the examinations, and run the laboratories, the division of time is as follows:

Advance lessons with recitations	74
Review lessons on problems	4
Lectures, demonstration and review	19
Examinations, two hour	4
Laboratory periods, two hour	21
Total periods	122

The periodic lectures are not a means of determining proficiency, but for demonstrations, to coördinate the course, to emphasize important concepts and laws, and to fill the gaps in classroom instruction. In the laboratories we are able to handle one battalion of about 125 men each afternoon, keeping an even front with only two experiments running at any one time, with only two midshipmen working on any one set-up, so that even the practical works are in step with the classroom instruction.

After seven weeks of recitations, a week of examinations is given to all the midshipmen. Before the examination questions are approved, three of the officer instructors must work the examination against time. An examination for which the midshipmen are allowed 110 minutes, must be worked by the officers in 65 minutes. A trained teacher could readily work it in 45. This checks the difficulty of the questions, avoids unimportant or tricky questions, and assures that the required answers will be definite. This method is not patented, and is recommended to all of you.

In the Naval Academy there is a very definite marking system. Marks are by necessity a fetish to which worshipful devotion is paid. The class standing of all men is determined by their work in the classroom, and this class standing, as *Fortune* puts it "establishes for all time your standing in the navy hierarchy." Forever after you will work side by side with your classmates of higher and of lower standings, and your rank and chances for promotion will be determined by the class standing. In determining the final mark the average of daily recitations is given a rating of 60 per cent, and the examination of 40 per cent.

Advantage of Discipline

The Naval Academy is primarily a military school, and as such the midshipmen are subject to a rigid discipline; every moment of the day, except for the 2½ hours from 4:10 to 6:40 in the afternoon, is occupied with required duties; attendance on all classes is required and is on time; there is a rigid routine and a supervision of every hour; violations of the multitude of rules and regulations bring demerits and punishment periods; dress is not individual but is uniform; rates and restrictions govern the student body; and the habit of obedience is developed both by precept and by necessity.

There are certain inherent advantages in a well disciplined student body: a uniformity of sensible dress seems more fitting to a young man than the jitterbug, scare-crow ensembles found on many of our campuses; under the system of discipline the majority of young men become alert, attentive and self-possessed to a great degree; no week-ends in the near centers of night-life and no cuts

from classes are allowed; the habits of obedience to proper orders, of loyalty to superior officers and to classmates, of proper behavior in the classroom, the athletic field, or in daily life, are fostered; and the adolescent grows up to be a man, trained by habit to respect the rights and rates of others, and to take his place as an important molecule in the vast cosmos. He has been trained to fit himself into an harmonious and complex system.

It has not been necessary for the Committee on Un-American Activities to investigate the Naval Academy; no "isms" of any cult could live long in the patriotic atmosphere of this democratic institution. The members of this student body are selected by an examination comparable to that used in the best engineering schools from all parts of the United States. They are housed in a single dormitory, eat and attend class together, and are in close association continually. There is no place for social cliques based upon economic condition, ancient lineage, or standing in the Blue Book or in Dun and Bradstreet of their progenitors. The son of Baroness Wrangel, the cousins of the Vanderbilts, the son of the Podunk barber, of the dust-bowl farmer, and of the WPA timekeeper, exchange ideas, work together, and become close friends. Nowhere else, except for the Military Academy, does an institution approach the democratic ideal that "all men are free and equal." During the past week we had visiting us a plebe who was just accepted on Friday, and the last word of warning we gave him was not to let it be known that he was of the F. F. V's, with medalled ancestors in the Revolution, the Civil and the World Wars, that he had been president of his class, and voted the most likely to succeed. Previous history is hidden, it is the performance which counts.

In that connection, we have no fraternities; to form an organization within the Academy is a Class A offense. Many of our colleges would be glad to find fraternities as defunct as the dodo bird and the passenger pigeon.

As the entrance requirements are high the young men who are accepted are definitely well above the average of the whole country mentally; are in perfect physical condition; and are not worried by money matters or by extra work. Thus the instructors do not have to allow for anomalous situations brought on by extraneous activities.

Educational Aids

In consequence of the large number of officer instructors it is necessary to make use of many educational aids in preparing the curriculum and the instruction, and in the actual classroom work. In order to coördinate the work of the various departments the

Academic Board, composed of the heads of the academic departments, meets regularly and passes upon all changes of policy, takes up the cases of delinquents, and irons out all matters pertaining to the Academy. In each department weekly conferences are held for the instructors in each subject; the work for the succeeding week is outlined by the head of the committee or by the senior civilian instructor, difficult points are explained, important points are emphasized, lesson analysis sheets are passed out and discussed. The material covered in each classroom is thus nearly the same, the idea being to standardize the methods and content of instruction. In my own case over half of my time is spent in the instruction of instructors, both in teaching methods and in physics, so that at the end of a year our officer instructors are better teachers and better physicists.

In every department there is extra instruction twice a week for those midshipmen who find themselves getting behind; in Navigation and some of the engineering departments approved solutions of the most difficult problems are passed out to the students; before each examination in physics we pass out about twenty important problems, and the five problems on the examination, with the data or the approach changed, are taken from these.

Probably nowhere in the educational system of the United States is the objective type of question and examination used so little as at the Naval Academy. This is not due to the inertia of the staff, or to the tradition of other types of questions. The Naval Academy can afford the luxury of small sections, and when the instructor has only fifteen papers to correct after each class, and only fifty after an examination, the chief advantage of the objective question is lost. In addition, there is enough guessing going on in the recitation without fostering the gambling instinct with True and False, or Choice and Chance questions. As Captain Smith says in his report:

> With responsibility to confine the operation of its ships to deep water and to return its planes safely to their carriers or bases, the Navy cannot teach Navigation by the "vocational" method.

Facilities

On the side of material the buildings and equipment of the Naval Academy are of the best. Where colleges depend upon endowment, tuition fees, and the alumni, the Academy must secure an annual appropriation from Congress, and although this never equals what is asked, it is usually sufficient. The Department of Electrical Engineering, in order to buy apparatus and machines, and replace obsolete equipment, is allowed $15,300 for the four

courses that are being taught. In addition the services of two clerks, two laboratorians, and nine civil service employees of various ratings are available, these being paid out of another appropriation. For our sophomore physics course we are allowed $3500 with which to purchase equipment, all of this money being spent for operating the undergraduate course, for laboratory and lecture purposes—none of it being spent for graduate work or research. Contrast this with the undergraduate work of one of our best known technical schools, where with a million dollar laboratory, and money poured into research apparatus, a mere $800 annually is available for the 600-men undergraduate sophomore physics course.

Many of our colleges and universities are not playing fair with the student bodies. Money which has been collected to further undergraduate teaching is being diverted to the uncertainties of research. In many universities a man cannot secure a teaching position except by reason of his abilities in research. The leading lights of the various departments are so occupied with "maintaining a schedule of pointer readings" that they have time only for six hours of teaching each week, and that often of a perfunctory nature. Certainly in our colleges teaching ability should be recognized, for believe it or not, a college exists to teach its students. The good teacher is one with the broadening influence of many interests, he might even be a William Lyon Phelps and a Rotarian, rather than one narrowed by the restricted and rigorous requirements of advanced research. The Naval Academy has been criticized for not fostering research; that is not the function of an educational institution, but rather of the research laboratories like Langley Field and Bellevue where trained men may work without the disadvantage of a divided interest.

Practical Works

From the time that a plebe enters the Naval Academy he is drilled and trained in practical subjects so that the theory of the classroom is correlated with actual practice. During plebe summer, infantry and gunnery drills, firing of rifles and of small guns, are interspersed with trips to the library guided by experienced instructors, and work in the mathematics class on slide-rule, trigonometrical and logarithmic computation, and intensive reviews.

During the academic year, periods for practical instruction are allotted to the various departments given. (Table on following page.)

It should be noted that the Executive Department has periods devoted to leadership, service traditions, economics and insurance;

the Marine Engineering Department includes mechanical drawing, descriptive geometry, mechanisms, heat engines and thermodynamics; the Electrical Engineering Department includes Chemistry, Physics, Electrical Engineering and Radio; and other departments are similarly divided.

After the plebe year the midshipmen are taken to sea, often for a foreign cruise of three months, in which they learn life aboard ship, and are given instruction in watch standing on deck and in the engine rooms, in the actual mechanisms encountered, and in practical seamanship.

Department	Classes					
	First	Second	Third	Fourth	Total	Per Cent
Recreation	10	10	10	10	40	6.4
Executive	48	47	42	42	179	28.6
Seamanship and Navigation	19	20	28	33	100	16.0
Ordnance and Gunnery	30	23	13	7	73	11.7
Marine Engineering	20	21	28	32	101	16.2
Electrical Engineering	14	22	21	22	79	12.6
Physical Training	14	9	10	20	53	8.5
Total for Four Years					625	

After the third class year three months are spent at Annapolis and on a destroyer cruise in home waters. Aviation is studied to include flights as navigator, radioman, and observer; nine lectures in the Applications of Physics are given; elementary laboratory in electricity is started; over 100 hours is spent in the laboratories in Marine Engineering; a reading course in English from selected books is taken; and practical ship handling is continued.

At the start of the First Class year another foreign cruise is scheduled. This is chiefly given up to practical navigation and seamanship, with about one-third of the time given to engineering practice, practical radio and electricity, practical ordnance and target practice.

For accrediting purposes it has been computed that the summer courses and practice cruises amount to 16 semester hours in academic subjects during the four year's course.

Culture and its Lack

Since the beginning of engineering education the liberal arts colleges have been criticizing the engineering schools as producers of objectionable dungaree artists, lacking in culture and the finer

things of existence, knowing not the difference between Leonardo da Vinci, Ibanez, and Tony Galento. The Naval Academy has received its share of this unjust criticism. Let us examine the record.

Out of 131 term hours in the four year's course, 31 are assigned to the Department of English, History and Government, and 13 to the Department of Modern Languages. Reading of selected books starts the first week a plebe enters, and finishes two years after the commission of Ensign is won. This percentage of time exceeds that of most of the technical schools of the country. Culture is furthered by the close association with young men from every social level of the country, by the social functions attended, by the athletic contests participated in, by the foreign countries visited, by the occasional meeting with celebrities, and by the cultured and leisurely air of colonial Annapolis.

Conclusion

Gentlemen, I give you an institution where the chapel includes the remains of our greatest Admiral, John Paul Jones; where the yacht America rests from its victories of peace, and where the motto is the dying phrase of Lawrence, "Don't give up the ship." I give you an institution which in one year, in competition with all other schools of the country, was awarded six Rhodes' scholarships. I give you an institution whose graduates include Michelson, who first accurately measured the velocity of light; Maury, who pioneered in the science of oceanography; Mahan, genius in the science of naval strategy; and Durand, Dean of Engineering and President of many societies such as this.

Such an institution should not have to open up with the mighty blasts from her major caliber guns in order to answer the feeble pop-guns of her captious critics.

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INTERMEDIATE PHYSICS IN THE ENGINEERING PHYSICS CURRICULUM *

By CLARENCE E. BENNETT

Head, Dept. of Physics, University of Maine

My subject naturally divides itself into two parts: (1) A consideration of intermediate physics, about which much has been said and written, and (2) The question of the engineering physics curriculum (sometimes called applied physics) which also seems to be attracting considerable attention these days. It is not my intention, however, to make a sharp distinction between these two matters, but rather to emphasize, if possible, certain relationships existing between them in the hope that something may be said that will stimulate discussion, which in turn will throw added light on the subject.

The speaker was attracted by one statement in particular which was made in the report by Professor Lapp and his committee on tests of the American Association of Physics Teachers published in the *American Physics Teacher*, Vol. 6, 1938, p. 85. One of the conclusions of this study is, "Much material that has been generally accepted as basic to all future courses in this field, is very imperfectly understood by students completing a first course. The 'half-learning' revealed by these tests indicates in arresting fashion that even in the most highly selective institutions, a necessity exists for strengthening the student's comprehension of those fundamental facts and concepts that are the indispensable substratum for critical or creative thinking in advanced physics courses."

Needless to say, this report confirmed the speaker's already formed conclusion that the prevailing type of first-year college physics course does not provide a sufficient background—it being a necessary but not a sufficient one—for the student who wishes to make this material serve as the basis for future building along professional lines. The argument is particularly applicable to the training of engineering physicists, if not indeed to the training of engineers generally. That this is admitted by all, is borne out by the current practice in different institutions to increase the stu-

* Presented at the 47th Annual Meeting, S. P. E. E. (Physics), Pennsylvania State College, June 19–23, 1939.

dent's comprehension of fundamental general physics by the following plans:

1. The offering of specialized courses in the different branches of physics to follow the first course, each one to start practically at the beginning.

2. The spreading of the ever-growing body of material comprising the first course over two years, as is done at M. I. T. and other schools.

3. The covering of general physics twice, first by a freshman course of the prevailing type and then by an intermediate course of a more mathematical nature in the second year, this second course being, generally speaking, of the type illustrated by the Bayley and Bidwell text, "An Advanced Course in General College Physics," published by Macmillan Company. Parenthetically, it can be said that the term "Intermediate" might well be substituted for "Advanced" in the title of this text. Of these possibilities, the speaker wishes to call particular attention to, and make a special plea for, the last one, knowing full well the limitations involved.

In the first place, there are many arguments against the first plan. It leads to a situation in which essentially elementary and intermediate material are included in so-called Advanced Courses in Physics, some of which come as late as the senior year. This is unfortunate because there is so much more that can be introduced in advanced specialized courses on the undergraduate level if the concepts and relationships in general physics are thoroughly digested by the student before the advanced work begins in any branch of the subject, including modern physics. Moreover, the student may not be able to cover the whole subject in this manner and thereby, he may get a distorted view of the relative importance of the various parts of it. The speaker predicts that the time is not too distant when this plan of following the first one-year general course by specialized courses will become obsolete.

The second of the above mentioned plans is growing in popularity. It is increasingly obvious that the material to be covered in general physics is outgrowing the conventional one-year treatment. To many, this points definitely to the need for two years over which to spread it in four consecutive semesters. To others it does seem unfortunate, however, that those students who cannot complete such a two-year program may never get as much as a freshman acquaintance with certain branches of the subject, and that correct perspective is also endangered by so increasing the gap between the last portion studied and the first—a matter of nearly two years. Moreover, this plan pre-supposes that all the students who start upon the two-year program are seriously in-

terested in the subject and that the thoroughness with which it is possible to cover the material will be of unquestionable benefit to the whole class. Experience has shown the speaker that much of the analytical material presented in the first courses in general physics fails to impress an appreciable fraction of the class, even when it is made up of engineering students. Of course, the instructor's first reaction is that such students are not fitted for engineering or professional work in physics, but this conclusion is often unwarranted. It may merely mean that some students cannot see at the time why such derivations are worth while and hence they require more than a normal share of instructor attention. Therefore, since much energy is expended, if not actually wasted, in trying to get material "over" to many confused students who justly demand good reasons for the exhaustive treatment of details tending to obscure the general outlines of a subject, which we boast to be highly organized, it seems clear that the third proposal above, which avoids these difficulties, is worth considering.

A second course over the whole field of general physics seems particularly fitting for the survivors of the first course, who not only have a clearer outline of the subject and appreciate the necessity for rigorous treatment, but are better prepared mathematically by that time, and who incidentally comprise a much smaller and undoubtedly much more serious group than the former one. Certainly this way of utilizing two years has the advantage of reserving the most difficult parts of the subject for those who have been prepared for them instead of frightened away from them, and of leaving room for the introduction of additional qualitative material in the first course. Moreover, if students find, after the first year, that they are not fitted for technical courses, they have at least acquired an integrated picture of the science without having wasted what to them would undoubtedly seem like a great deal of time. More important, however, are the facts that the survivors of the program do not lose sight of the forest for the trees, half-learning is reduced, and general physics becomes a real background for advanced work.

Such a plan as this has been in effect at the University of Maine for the past three years and has proved very satisfactory. It is an outgrowth of a special second-year course in general physics for college transfer students at the Massachusetts Institute of Technology where it was found by the speaker,* that such a course was capable of supplementing the conventional one-year course completed by all students before transferring to the Institute. It is conducted on a six-semester-hour basis with three informal lecture

* C. E. Bennett, *American Physics Teacher*, Vol. 2, Dec. 1934.

recitation meetings per week, without laboratory or lecture demonstrations, although a supplementary one credit hour laboratory course is recommended. One decided advantage of the plan, incidentally, is the ease with which it can be introduced into an existing curriculum to increase the scope of general physics without upsetting well established programs. At this institution the course in Intermediate Physics also constitutes the major sophomore course in the new Engineering Physics curriculum. Although the latter has been in operation only one year, there is a very clear indication that during the junior and senior years certain rather substantial courses decidedly above the intermediate level can be taken with considerable appreciation by the students with this background.

It is certainly clear that a thorough mastery of the field of general physics is essential to those students to whom we are giving a training in physics in an engineering atmosphere to make them useful in industry. It is highly desirable that they have a well balanced view of the situation rather than one distorted by a high degree of early specialization in certain portions at the expense of others. Industry is only too familiar with the graduate in physics who may be qualified to deal with certain minute aspects of, let us say, the field of nuclear physics, but who has not gained sufficient familiarity with Newton's laws of motion to apply them to simple but out-of-the-ordinary engineering problems. It is moreover, certainly a mistake to think that this material can be mastered by even the best student in the best institution in a single year's course devoted to the study of general physics. It takes time to digest a topic and such time is not available before a new topic is taken up. In the second course, however, a year has elapsed since the material was presented on the college level and the relationships of the topic in question to other topics have been considered. A very brief review brings the topic to mind and the way is paved for more mathematical derivations and more difficult problems. Indeed many a student has completed his formal study of the general, as distinguished from the specialized, aspects of physics without determining the connection, if any, between, let us say, polarized light, perhaps one of the last topics studied in optics, and simple harmonic motion studied approximately two academic years before. It is the author's contention that teachers should realize this and admit that only a relatively small number of their students ever get all of these fundamental facts straightened out, to say nothing about getting that comprehension mentioned in the committee's report.

Now lest it seem that the speaker is unduly enthusiastic about the type of intermediate course just described, he wishes to recall to

your minds his statement that he knew full well the limitations involved, although he does feel that the advantages outweigh the disadvantages. In the first place, there is the strong temptation for the instructor to dwell too long on each topic. But experience teaches that it is wisdom to resist this temptation. The intermediate course cannot be made into an advanced course and, because of the above reasons, this should not be attempted. It is found that convenient stopping points can be discovered. In the second place, there is the rushed feeling that grows out of an attempt to cover the whole subject in a single year. Again experience teaches that some selection of subject matter is not only possible, but desirable. Certain minor topics can and should be omitted without interfering with the continuity or the balance of the material. This serves to bring out the point that the course is not just a repetition of the first one, but that it is an entirely different one which, incidentally, is not to be passed off too lightly by the instructor. Admittedly, this type of course taxes the instructor considerably to cover as much material as possible, to review the topics by just the right amount and no more, to find problems of just the right degree of difficulty, and to stimulate the students to want to go further. But is this not what the teacher is for?

In conclusion, then, it would seem that the case for a second course of the type described is a strong one. The advantages gained by postponing specialization until after the general phases of the subject are mastered in proper balance should not be treated too lightly. Brief repetition is desirable so long as it is brief, and the short reviews preceding the mathematical discussions of each topic accomplish just this. A further advantage is the ease with which such a course can be introduced into the curriculum. In the hands of a good teacher there seem to be limitless possibilities offered by a second general course to give the student a better grasp of fundamental physics on which to build for the future.

FACTORS OTHER THAN INTELLECTUAL IN THE TRAINING OF AN ENGINEER*

By JOSEPH E. RAYCROFT, M.D.

Professor Emeritus, Dept. of Health and Physical Education, Princeton University

Educated man in every civilization has recorded his recognition of the fact that he was "living in a changing world." One would think that by this time man would have become accustomed to changes and would have learned how to foresee and provide solutions for the new problems of living that arise from changing conditions.

It is only fair to say that in the past man has been reasonably successful in adjusting himself to new conditions, favored as he was by the fact that generally the changes had a slow tempo and ample time was available for the process of readjustments in the social and cultural pattern.

In modern times, however, changes in standards, desires and activities due to discoveries and inventions follow each other at such a rate that our pattern of life has become wavy and confused and our sense of relative values less acute. It is obvious that the automobile, the motion picture and the radio—to mention only a few examples—have been factors in bringing about important changes in habits of life; but the most disturbing and vital changes have developed in family life. There has come about a definite loosening of family bonds and a lessening of inter-dependence and team work that tend to limit the family contribution to the training of its members for successful living.

As a matter of fact, nowhere has this change in family life had more important consequences than in the field of education; and the statement appears to be justified that no group, except possibly the church, has been slower than the educators to recognize the situation and by analysis and diagnosis to bring about those changes and adjustments in the scope, attitudes and techniques of the educational process that are necessary for success in dealing with the young human animal as he actually exists in the world today.

There is an element of poetic justice in the fact that the Deans of engineering schools—those handmaidens of that body of scien-

* Presented at the 47th Annual Meeting, S. P. E. E. (Orientation), at the Pennsylvania State College, June 19–23, 1939.

tific knowledge and discovery that has revolutionized modern life —should be among the first to feel the pinch of the resulting problems in their training of engineers. On the other hand, you can get satisfaction from the fact that you do recognize a real but intangible change in the material that comes to you for training and are taking steps to find out how best to prepare it for dealing with new situations.

I am not competent to discuss the scope and content of your courses, or your methods of teaching and training engineers. I am quite convinced, however, that the boys that come to you and to other colleges and universities differ in certain vital respects from those that came to these institutions a generation or more ago. I do not say that the human material is *inferior*—for in some respects it is better trained and further advanced in intellectual attainments—but I do say that it is *different* and that it requires a corresponding change in methods of handling so that the necessary knowledge may be absorbed—and more important still, so that the training acquired may be utilized effectively.

How Does the Modern Boy Differ from Earlier Generations?

Now, the ability to take advantage of opportunities for sound technical and scientific training and to put it to practical use depends upon the possession of certain qualifications: a sound healthy body, self control, persistence in effort, self confidence without being bull-headed, the ability to get on with and coöperate with others, and a sense of relative values that will enable one to disregard the disappointments and misunderstandings that are common in the life of every individual—in other words, to possess a well-balanced personality.

Intensive studies of young persons during the past twenty years or so indicate that there is an increase in the number of adolescents who are unequally developed; *i.e.,* physically and intellectually they correspond with chronological age, while emotionally they are untrained and immature. Students of personality are of the opinion that the underlying cause for the existence in physically sound persons of emotional instabilities, undesirable attitudes, indifference, combativeness, and other signs of maladjustment have their roots in childhood. These characteristics may exist in varying degrees, may persist throughout life—serving as points of weakness under stress and strain—or they may be replaced by more desirable qualities in a different environment under more favorable influences and as a result of a process of reëducation.

In any event, the responsibility for the development of these traits is generally attributed to the profound changes that have

commonly taken place in family life and relationships. It is important to realize that this phenomenon is quite as apparent in families that are comfortably well off as it is in the very rich or the poor. I'm not at all sure that the children in the latter group do not enjoy certain *advantages* due to the fact that they may have to contribute to their own maintenance and to the family welfare by some form of work. "Work may be exactly what a youth most needs, not only for economic reasons, but more particularly because of the value of the work emotionally and in the building of habits, skills, knowledge, character and self reliance." *

For many generations, parents of all classes were in a position to fulfil their functions as natural educators of the child's emotional life; while the school teacher furnished the systematic training of the child's understanding and intelligence. In other words, these two processes went along side by side. But as the family life has changed under modern conditions, the influence of the family has lessened, and more responsibility has fallen upon the school to recognize and provide for the needs in the emotional training of the child. General education has not yet fully realized this need —nor is it equipped to satisfy it.

In addition to these general changes, there are other specific factors in early life that tend to interfere with normal emotional control; *i.e.,* over-protection by either or both parents; deprivation of initiative; "broken" family; financial troubles; or such conditions as: physical inferiority or handicap, endocrine disturbance, stammering, etc.

Development of Personality Problems

These factors serve as the ground-work of personality problems: emotional immaturity, anxieties and tensions, feelings of inferiority, introspection, intolerance of criticism, irresponsibility, evasiveness, lying and inability to face unpleasant facts.

Such types of personality react badly under pressure of academic or social competition, family or financial difficulties, or—less commonly—sex impulses. These stresses commonly find their expression in worry, introspection, insomnia and procrastination, or body protests such as eye trouble, digestive or cardiac upsets, asthma or other symptoms for which no physical cause can be found.

New Responsibilities for the Inexperienced

For such boys the modern engineering school presents a brand new set of problems and responsibilities. The boy who has had

* Gulick—"Education for American Life."

some college experience has had a chance to adjust himself to this type of life; but the one who comes directly from the well ordered, closely supervised life of the "prep" school, or the student who has lived under home influences while attending day school, finds himself abruptly confronted by freedoms and responsibilities with which he is quite unfamiliar. His program of courses is much broader. His ability to make wise choice is undeveloped, and unless he is unusually fortunate he has not yet decided upon his major line of interest among the many possibilities that are available. This new situation calls for planning, decisions and self-guidance that furnish opportunities for mistakes that may represent serious handicaps to his progress. However wisely he may plan his program, he still is confronted with a heavier load of work assignment, more independent reading, and generally is lacking in experience in digesting what he reads and in taking useful notes on lectures.

Also, there is a strong impulse on the part of all, except the boy who is seclusive—a condition that calls for immediate and understanding investigation—to make a place for themselves and to achieve some prominence among their fellows. This the student attempts to gain by success in one or more extra-curriculum activities that constitute so large and valuable a phase of life in modern institutions. Add to these problems the necessity for the wise use of leisure time, and it becomes obvious that the youth who has not learned how to budget his time and energy is in great need of help and guidance, particularly during his first year—and in some cases well along through his course. These conditions, though touched upon in barest outline, represent a very severe test of the character and judgment of the boy and his ability to plan and work effectively and to avoid undue emotional stress and strain.

Who Gets into Trouble—and How Does He Stand It?

Attention should be called at this point to several conclusions that are generally accepted by men who have had much experience in dealing with student problems:

a. That, on the average, two out of every three boys who experience difficulty in making a satisfactory adjustment in college are in the intellectually superior group; and

b. That, while the good natured, careless boy of fair to good capacity and poor habits of study may, and frequently does, show evidence of maladjustment under stress, yet with the aid of wise counsel he is generally able to shake it off, "snap out" of his troubles and do a better job with no particular feeling of guilt or hurt pride;

c. Whereas a more serious problem is presented by the intellectually able, but emotionally immature, sensitive and conscientious students who are more susceptible and suffer more deeply, and whose efforts to adjust are handicapped by loss of confidence, a sense of inferiority and frequently by body protests.

These emotionally immature boys stand these experiences badly and unless the underlying reasons are recognized early and adequate treatment made available, the result may be a real mental breakdown—or at best loss of confidence and a crippled personality struggling against heavy and uncorrected handicaps. That this superior boy is worth and needs help is shown by the fact that 15 per cent to 20 per cent of the highest honor men in one institution needed and were given psychiatric help during the college course.

Many Factors Affect Training

So the problems in the training of engineers are not solely intellectual. The material that comes to you has been winnowed repeatedly and few present themselves who are lacking in mental capacity. Your problem lies in another field which has to do with personal qualities, attitudes and characteristics that not only influence sound and continued progress in learning, but also are fundamentally important in the practical application of knowledge.

Engineering is not a cloistered profession. The criteria of success in this field are not the composition of literary phrases, philosophical formulæ, or the writing of books. Success is judged by objective achievements made possible by: knowledge which leads to the correct answer to a physical problem; a personality that helps to convince the man with the problem that the answer is correct, and the administrative ability to transform the plan into a smoothly functioning physical entity.

Your material comes to you at a period in life when personality characteristics are already formed, but they are still plastic and are capable of being modified in a new environment under proper influences. We do not hesitate to apply special measures—such as tutoring—to correct deficiencies in academic subjects, or by exercise or vaccination to improve body conditions. No more should we hesitate to undertake to correct and strengthen weaknesses in the emotional field.

In the course of the past fifty or seventy-five years, carefully controlled studies of individuals—young and mature—have furnished us with a reliable body of knowledge about physical growth and development and about physical health and its modifying

factors. These studies have been supplemented by the development in recent years of a better understanding of inter-relationships of physical, mental and emotional factors in an individual. In other words, the development of a concept of the wholeness and unity of the personality.

A few institutions in the country have recognized the importance of the problem and have made adequate provision to meet it with a procedure that is both preventive for the group and corrective for the individual. The administration of this phase of the educational experience at the college level calls for the services of competent doctors and psychiatrists and the coöperation of supervisors of extra-curricular activities, department heads and Deans. The procedure varies in detail in various institutions, but is the same in principle:

The problem really is a double one—first, the correction of the condition in a given individual, and, second, the provision of a general program that will serve as a prophylactic and a deterrent to the development of other cases in your student group.

Analysis of Student Material

The essential first step is to make a thorough and adequate survey of your material. As soon as possible after admission to the school, each boy should be given a searching and discriminating medical examination and a preliminary study and estimate of his personality. These observations should be given very careful consideration in the light of other information from the family on specific points in his past history and experiences, and the replies to a carefully formulated set of questions to be answered by the boy himself, which will furnish useful information in about 75 per cent of the students. All of this information should be collected during the first days of the year and will serve as an invaluable background against which to consider the characteristics that may lead to failure, or signs of maladjustment that may be present, and as a basis for a diagnosis of the conditions and a program of treatment.

This material and the information gained during the first year and a half can be supplemented to advantage by a special letter sent to each sophomore just after midyears. This letter states in effect that the college is anxious to be of the greatest possible help to the student in perfecting his plans for the future. It invites him, if he is willing, to send to the Dean or medical office a confidential report—as intimate in character as he cares to make it—outlining his estimate of the kind of person he thinks he is, his handicaps, ambitions and what he hopes to make of himself.

Dean Hawkes of Columbia recently reported on the results of such letters. Over 90 per cent responded and listed topics and problems of various types that affected their work, and their plans for the future which they would be glad to discuss with the advisor.

It is not unlikely that attention might be called to some among the ten per cent who did not respond—and whose records might suggest that they were in need of help.

Technique of Individual Help

Nothing is more important in this work with young men than a matter-of-fact and objective attitude. An over-solicitous and intrusive manner repels and limits the chance of securing confidence and coöperation. The results of this program will vary in individual cases. In some the trouble will be surprisingly easy of correction. In others, the need for help may arise at intervals throughout the course. In any event, at some time or another advice as to program, methods of study, extra-curriculum activities, etc., should be supplemented by discussions to enable the boy to understand himself, to recognize his own handicaps, and to point out ways to overcome them.

Group Activities

The next essential is to provide an atmosphere and opportunities that are favorable for healthy associations and activities in the business of living—athletics for all tastes and abilities; publications; dramatics; and especially responsibility for self-government. There is no sterner disciplinarian than the captain of an athletic team, the student editor, or the president of a dramatic organization. Smartness in decision and action, persistence in work for improvement in performance, determination and a disregard of personal discomfort, and many other worthwhile results arise naturally in the practice of such activities. Above all—to give the student the fullest possible control within agreed-upon-limits in such activities—education is more than the acquisition of knowledge—it is practice in living.

All this requires a clear plan, and skilled direction. Your medical and psychiatric service are the foundations but the coöperation of the administration, the personnel director and advisors is essential.

The process of "growing up" and the development of emotional stability and mature judgment in these modern times appear to be more difficult than ever before. Mistakes are more heavily penalized and there are fewer chances for recovery from the consequences of failure. In these days, a boy "dropped" from one college is

not readily accepted elsewhere. It is more difficult for the untrained, or partly trained, person in any field of endeavor to break into a good job or to make his way in competition with those of superior training. As a result, feelings of frustration, discouragemen and inferiority develop and are magnified by uncorrected weaknesses in the personality of the individual.

In view of the fact that maladjustments are proportionately more common among the emotionally immature, intellectual lads who have innate capacity to do a good job in life, this program for the early recognition, diagnosis, and treatment of the emotional instabilities is of fundamental importance. It not only preserves and utilizes first-rate material, but it conserves the time and effort of the teaching staff and makes their work more effective.

Few of us are able or willing to judge our flaws and handicaps objectively. The longer they persist unrecognized or unacknowledged, the more fixed they become. Hence the importance of individual assays early in the educational experience so that when signs of failure or maladjustment appear a reliable basis will be available for dealing with the boy in such a way as to bring him—for the first time perhaps—face to face with himself and to help him to overcome and correct his emotional or physical handicaps or to arrive at satisfactory adjustment *to* them. Experience has shown that upwards of ninety per cent of such cases can be helped gradually to attain a stable adjustment and to maintain high standards of work during a college course, but still more important to make a success of living. Surely this is a result which is worthy of our best efforts!

EVALUATING THE ABILITY OF STUDENTS TO DO THE WORK OF THE UPPER CLASSES IN THE ENGINEERING COLLEGES *

By WILLIAM H. FORMHALS
Assistant Professor of Electrical Engineering, Lehigh University
AND
BRADLEY STOUGHTON
Dean, College of Engineering, Lehigh University

Introduction

A comprehensive study of engineering education † lays special emphasis on the wastefulness of one phase of our educational processes, namely: Average figures for our American engineering schools show that 56.5 per cent of those who enter never graduate, and only 28 out of 100 of them graduate with the class with which they entered. This compares unfavorably with corresponding figures for the schools of law and medicine.‡ But the report further says that more than one-half of the elimination in the engineering schools is in the first two years, which two years, it says,§ do not put any strain on a student's engineering aptitude. It is obvious that the highest possible selectivity should be used for admission to engineering schools, but, even if this is practiced, it has not been found possible to devise a type of selectivity which admits as freshmen only those students who can successfully survive the first two years.‖ In addition to recommending good selectivity for entrance, the report also recommends selectivity for entrance to the junior year.¶ In conjunction with this selectivity at the end of the sophomore year, it suggests that students with only a "fair record" at that time be permitted to transfer to non-engineering, or be honorably dismissed.** It suggests that associateships in engineering might be issued at the completion of the first two years' work, or that prospective failures be advised to withdraw without stigma of actual

* Presented at the 47th Annual Meeting, S. P. E. E. (Comprehensive Examinations), Pennsylvania State College, June 19–23, 1939.

† "Engineering Education," Report of the Investigation of Engineering Education, 1923–1929, published by the Society for the Promotion of Engineering Education, Vol. 1, 1930.

‡ See pages 26, 200, 205, and 225.

§ Page 205.

‖ Page 212.

¶ Pages 100, 101, 104, 181, and 182.

** Page 101.

failure or further loss of time, and a certificate be issued as to an intermediate level of accomplishment.††

Criteria for Selectivity

The report also points out that scholastic grades obtained by the usual types of examination and marking have a relatively low correlation as an index of future student achievement,‡‡ especially on the borderline between passing and failing, and are a poor criterion of future achievement.§§ On the other hand, aptitude tests and placement tests have good predictive value.* Because the present type of examination is the best index we now have of scholastic ability, it is used in engineering colleges as a test by which to determine who shall remain in college and also who shall graduate. Those who pass the tests with high marks stand at the top of the class in graduation; those who fail miserably are eliminated during the first two years. Between these extremes is a group which often manages just to drift along. The presence of this group lowers the grade of work done in classes and deteriorates standards for graduation. Some colleges attempt to meet this situation by raising the grade required to permit an undergraduate to remain in college—in other words, they use the same type of standard but a smaller mesh of screen to lift out the undesirables. Other colleges deliberately avoid this method, even though they have a greater demand for students than they can accommodate, on the ground that, although a scholastic grade is the best criterion of measurement we now have, it is not an absolutely reliable one. At other engineering colleges different types of examination have been investigated without really solving the problem. Professor L. M. K. Boelter of the University of California † has discussed this question. Professor C. J. Lapp ‡ reviews the whole subject and emphasizes the need of tests to measure the ability of a student "to think, to reason, to meditate, to make connections, and see relationships between objects, events, and acts, to make abstractions and to draw conclusions." He adds, "Surely these are the most precious jewels developed by education if they are developed."

Most customary examination procedure (hour quizzes, final examinations, etc.) measures the students' ability to reproduce infor-

†† Pages 213 and 214.

‡‡ Page 698.

§§ Page 698.

* Pages 698, 702, 705, and 735.

† "The Comprehensive Examination; Does It Apply to the Engineering Curriculum?," Journal of Engineering Education, Vol. XXVII, 1936–7, pp. 5–404.

‡ "Physics Placement and Achievement Tests," Journal of Engineering Education, Vol. XXVIII, 1937, pp. 3–222.

mation obtained from texts, lectures, and discussions. Of course it is possible in some subjects to test as well reasoning power of students, but in most freshman and sophomore work this is somewhat limited. It then becomes necessary to set up another examination to test reasoning power, making such an examination as free from factual information as possible. This the examination developed at Lehigh University is designed to do. The 88 questions in this examination, as formulated, are intended to test the students' ability to apply information of a basic character to engineering problems rather than to state facts from memory.§

Name of the Examination

When the examination was first proposed in 1926, it was called a comprehensive examination. It was very soon learned, however, that the comprehensive type of examination did not test ability to apply basic information to the solution of an engineering problem, and thus was developed through years of study, correlation, and analysis the type of examination which may more properly be described as a sophomore engineering aptitude examination, or a general engineering aptitude examination, or an examination aiming to test a student's ability to do the engineering work of the upper classes. Some have objected to the word aptitude on the ground that an aptitude test is used for entrance. It should be noted, however, that these preëntrance aptitude tests are usually tests to indicate aptitude in mathematics, physics, etc., whereas a "general engineering aptitude test" is a type which could only be given after a student had had some instruction in the principles underlying engineering study and practice, and the name sophomore engineering aptitude test allocates this to a definite period in a student's education. The authors of this paper prefer the name "general engineering aptitude test" as being most descriptive of the type of test discussed herein. The name qualifying test has been suggested, but it becomes evident that, in order to test a student's qualifications to handle with full success the work of the junior and senior years in the engineering college, this general aptitude test is not alone sufficient.

Predictive Value of the Examinations

It was early learned that the examination mentioned in the previous paragraph did not alone sift out reliably those students who were not capable of pursuing the work of the junior and senior

§ "Sophomore Comprehensive Examinations at Lehigh University," by Charles W. Simmons and Bradley Stoughton, Journal of Engineering Education, Vol. XXVIII, 1937–8, pp. 5–378.

year. It is our belief that a man may be of value in professional engineering work, and likewise may be able to pursue successfully his engineering studies in his junior and senior years, provided either

(1) he has, to a superior degree, the ability to absorb and assimilate factual knowledge, and/or

(2) he can reason, from a given set of facts and a reasonable knowledge of basic scientific principles, to a logical and intelligent conclusion.

Admittedly, there are other characteristics which are important, but we believe they could all be included in one or the other of the broader classifications mentioned above. Obviously a man possessing both qualities (1) and (2) is the most desirable man to graduate in engineering. However, assuming that either of the two qualities listed above is sufficient to assure him his place in engineering work, it then becomes necessary to set up test methods to aid in classifying engineering students in respect to these two characteristics.

It is evident that scholastic grades alone do not predict future scholastic achievement with sufficient reliability to justify eliminating men from college unless they are in a very low group. There is very much too large a number of men in a median group which does well in the first two years and badly in the last two, or vice versa. Likewise, the results of the special test given at Lehigh University towards the end of the sophomore year and discussed previously do not alone afford a reliable criterion of future achievement, because there are too many individuals in the lower percentiles who ultimately graduate with their class. But, as indicated in a paper previously published on this subject,§ when a suitable combination is made of the scholastic grades of the first two years with the results of the general engineering aptitude test, there is better than a 90 per cent correlation between those who could be eliminated by this combination of criteria and those who were unable to graduate with their class. In other words, this paper showed that of a total of 538 men who took the examinations in the year 1933, 1934, and 1935 (classes of 1935, 1936, and 1937), 110 were in the lowest fifth in the aptitude test of the men in their individual curricula. Of these 110, 68 were both in the lowest fifth and also had a scholastic average of less than 1.50 on a scale of 4.00 for their freshman and sophomore years. Only 3 of these 68 men graduated from the College of Engineering in their original class.

Thus far we have assumed that the two qualities in which we are interested are knowledge and reasoning power, and that scholas-

tic records and what we have here called the "general engineering aptitude test" are means for measuring these qualities. It would seem desirable, then, to check these assumptions and, if possible, set up standards which, if not met, would disqualify students from continuing in engineering.

To do this most satisfactorily, charts were made up in an attempt to show the histories of the students taking the examinations; these histories to be based first on average scholastic performance for two years, and second upon the grade made in the general engineering aptitude examination. Two such charts, those for the classes of 1936 and 1937, accompany this paper as Fig. 1.

The lower chart of each pair uses the aptitude examination as the basis of comparison, while the upper chart uses the scholastic record. Each unit along the horizontal represents an individual student, while the vertical height corresponds either to his aptitude or scholastic grade. In each chart these grades are plotted in descending order and each student has been given a number corresponding to his rank in the aptitude examination. Thus by looking at a given number on the two charts for a class, it is possible to find both the aptitude grade and the scholastic average of that student.

Each block is then coded to represent the case history of the student. The coding has been so chosen that the poorer the individual's record, the blacker will be his block.

If conditions were ideal and the examinations perfect, we would expect that, reading from right to left, the blocks should start off with solid black, then through the shades of gray to white. The charts, however, show some erratic behavior, but in general we find the deeper grays and black towards the low end of the charts.

With these graphs, it now becomes possible to determine the predictive value of each of the two types of tests. After study, it was found that trouble is consistently indicated below a scholastic grade of 1.5 for the one chart and for the lowest 20 to 25 per cent of the other. However, in each of these groups, there are a number of white spaces, indicating that injustice might be done to several men by setting up a standard of elimination based on either test alone. Columns 1 and 2 of Table I show the results obtained from the charts accompanying this paper, using a scholastic performance of 1.5 and an aptitude standing of lowest fifth for failing standards. This indicates that, of those considered failing, from 20 to 33 per cent graduated with their classes. Obviously such a condition cannot be tolerated.

This great disagreement seems to indicate our original premise that there are two distinct characteristics required of an engineer

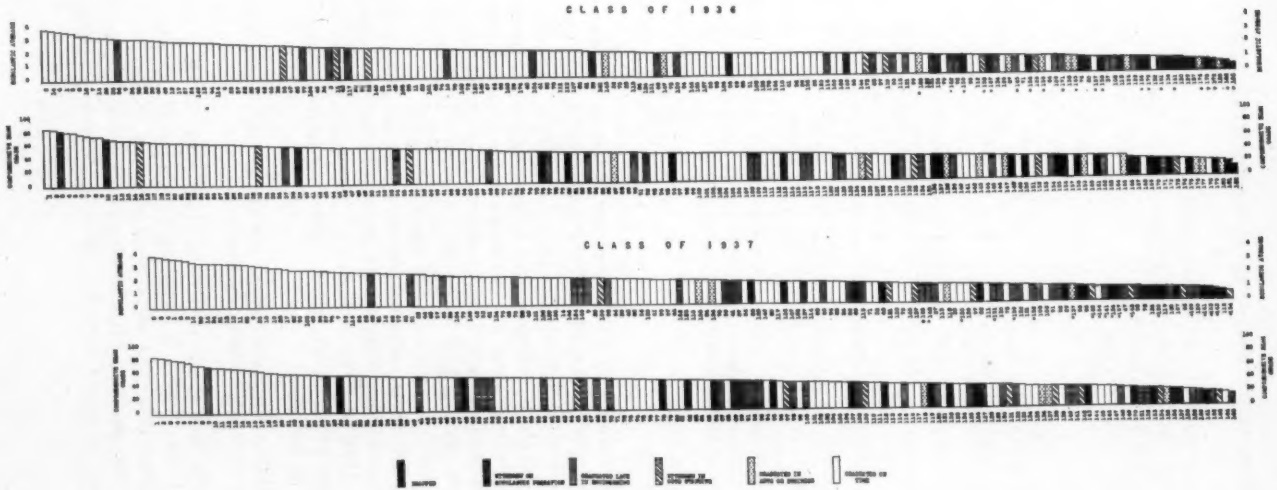

FIG. 1.

or engineering student—while he may show up poorly in one quality, his ability in the other will permit him to perform satisfactory work. The job then seems to be the setting up of standards to eliminate the man lacking in both qualities, and this would seem best to be done by setting up a double standard. If a man can qualify in either of the two categories listed above, he should be permitted to continue his work in engineering; if, however, he fails in both, he should be eliminated. On the accompanying charts, the asterisks indicate the men who have failed in both.

TABLE I

	1.5 alone		Lowest 20%		Combination	
	1936	1937	1936	1937	1936	1937
Total Considered	48	48	36	33	22	19
Graduated on Time	10	9	10	11	1	2
Withdrew Good Standing	12	5	2	4	1	3
Withdrew Scholastic Probation	10	4	7	2	6	2
Graduated Late in Engineering	10	17	3	9	2	7
Dropped	10	11	8	4	8	4
Graduated Arts or Business	6	2	6	3	4	1

The third column of Table I shows the results obtained when the double category is applied. Now less than 10 per cent of those falling in this classification graduated on time (all of these attended one or more summer schools to qualify for graduation). This represents less than 1 per cent of the total number (347) taking the examinations. Thus it would seem that the correlation of this double standard is about 99 per cent. It is unlikely that severe injustice to anyone would be done.

Although we have referred above to the classes of 1936 and 1937, for illustrative purposes, we have collected the data for all classes from 1936 to 1939 inclusive. The summary and details of these data are given in the three following tables, which we may recapitulate as follows:

Total number taking examination at the end of their sophomore year 808
Number in the combined lowest categories 105

Only 8 of these men graduated from the College of Engineering in their original class. This is less than 1 per cent of the 808 men who took the examinations, and less than 8 per cent of those in the combined lowest categories. All of these 8 men made up lost work by attending one or more summer schools, thereby boosting their records.

Conclusion

By means of the double category, we can eliminate from the junior class men who, for their own benefit and the benefit of the college, should not be permitted to go on, but whom we could not eliminate justly on the basis of scholastic grades alone. Admittedly, the number eliminated is only about one-half of those who fail to graduate ultimately, but we cannot dismiss a larger proportion at the end of the sophomore year without danger of injustice to individuals. It is hoped that a continuation of these studies may lead to further refinements, especially by the use of the charts which we have devised for this purpose.

Summary of the Sophomore Comprehensive Examinations

Given in 1934, 1935, 1936, 1937
Classes of 1936, 1937, 1938, 1939

1. Total number of men taking examinations		808
2. Number of men falling in lowest 20 per cent		163
3. Number of men in No. 2 with an average for 1–4 semesters of less than 1.50		105
4. Of these men in No. 3:		
a. Men graduating on time in Engineering		8
1. Men attending 1 summer school	5	
2. Men attending 2 summer schools	3	
b. Men graduating late in Engineering		10
c. Men graduating on time in Arts or Business		10
d. Men graduating late in Arts or Business		3
e. Men dropped for poor scholarship		34
f. Men voluntarily withdrawing from school		21
1. Men on probation when they withdrew	11	
2. Other men who had been on probation the semester before they withdrew	5	
g. Men still remaining in school in Engineering, May, 1939		14
h. Men still remaining in school in Arts or Business, May, 1939		5
		105

Summary of the Sophomore Comprehensive Examinations

By Classes

	Classes of 1936	1937
1. Total number of men taking examinations	182	165
2. Number of men falling in lowest 20 per cent	37	33
3. Number of men in No. 2 with an average for 1–4 semesters of less than 1.50	21	21

	1936	1937	Classes of 1936	Classes of 1937
4. Of these men in No. 3:				
a. Men graduating on time in Engineering			1*	2
1. Men attending 1 summer school	1*	2		
b. Men graduating late in Engineering			3	6
c. Men graduating on time in Arts or Business			2	2
d. Men graduating late in Arts or Business			2	1
e. Men dropped for poor scholarship			7	5
f. Men voluntarily withdrawing from school			6	5
1. Men on probation when they withdrew	5	1		
2. Other men who had been on probation the semester before they withdrew		2		
3. Last semester scholastic standings of these men	0.47–1.74			
			21	21

* This man entered Lehigh as a sophomore, coming from Stevens Institute with 47 credit hours.

SUMMARY OF THE SOPHOMORE COMPREHENSIVE EXAMINATIONS

By Classes

	1938	1939	Classes of 1938	Classes of 1939
1. Total number of men taking examinations			211	250
2. Number of men falling in lowest 20 per cent			42	51
3. Number of men in No. 2 with an average for 1–4 semesters of less than 1.50			30	33
4. Of these men in No. 3:				
a. Men graduating on time in Engineering			2	3
1. Men attending 1 summer school	1	1		
2. Men attending 2 summer schools	1	2		
b. Men graduating late in Engineering			1	0
c. Men graduating on time in Arts or Business			5	1
d. Men graduating late in Arts or Business			0	0
e. Men dropped for poor scholarship			10	12
f. Men voluntarily withdrawing from school			6	4
1. Men on probation when they withdrew	1	4		
2. Other men who had been on probation the semester before they withdrew	3			
3. Last semester scholastic standings of these men	0.74–1.11			
g. Men still remaining in school in Engineering, May, 1939			3	11*
h. Men still remaining in school in Arts or Business, May, 1939			3	2*
			30	33

* Probable. Figures based on Registrar's list of possible graduates, June, 1939.

THE DEVELOPMENT OF THE TEACHING OF MANAGEMENT TO ENGINEERS *

By CHAS. W. LYTLE

Associate Professor of Industrial Engineering, New York University

Single Courses

Most of us today had supposed that the single course started by Hugo Diemer at the University of Kansas in 1902 was the first bona fida course in Industrial Engineering and that the one created by Dexter Kimball at Cornell in 1904 was the second.† Certainly the texts resulting from these two courses were the first worthy of the name and most subsequent courses were influenced if not parented by them. But history is illusive and plays us tricks. This annoying questionnaire of mine started two men to real probing and this is what they found.

Both Virginia and Worcester Polytechnic Institutes had offered perfectly genuine industrial engineering courses in 1896! Now that we have rediscovered these cases it is easy to point out that it should have been so because Taylor gave his "A Piece Rate System" in 1895. The mystery to me is why no other courses were started until 1902 and 1904. Maybe there were some still-births. As to the discoverers, they were Professors Norton and Alford. I will let them tell their stories in their own words. Prof. Norton first—

In the V. P. I. catalogue for the year 1896–97 we find the first mention of two courses, both of which were listed as being for graduate students and both of which were taught by Professor L. S. Randolph then head of the Department of Mechanical Engineering and later Dean of Engineering. He was a member of the A. S. M. E. and much interested in the proceedings of that society.* The names of these courses were: "Engineering Contracts and Specifications" and "Shop Organization and Management." The description of the latter course was as follows:

The work in the class consists of a careful study of the principles involved in the management of large bodies of men; the organization of shops, factories, and railroads; methods of keeping accounts and the blanks used. The subject is handled entirely by lectures.

* Presented at the 47th Annual Meeting, S. P. E. E. (Industrial Engineering), Pennsylvania State College, June 19–23, 1939.

† The very first year Kimball's course enrolled 140 men.

* For sketch of his life see *V. P. I. Bugle* 1914.

The same courses with about the same descriptions were given in each of the annual catalogs up to and including the catalog for the year 1904–05.

In the catalog for 1905–06 we find the name of the course changed to "Corporation Organization and Management," also that the textbook used is listed for the first time, this text being "Manufacturing Costs" by Hall. We also find that the description of the course has been changed somewhat and is as follows:

The work under this subject consists of a careful study of the principles and laws of the organization of corporations; the management of large bodies of men; the organization of shops, factories, railways, etc.; the methods of keeping accounts and the blank forms used; the selection of machinery and the design and arrangement of buildings. Throughout the course the question of maximum economy or minimum cost in corporation management is kept steadily before the student, and he is taught to consider the elements of cost, including depreciation, repairs, taxes, etc.

In the catalog of the year 1908 we find that the name of the course has been changed to *"Engineering Economy"* and that no mention is made of the textbook used. The description of the course in the 1908 catalog was as follows:

Incorporation of companies, charters, by-laws, bonds, stocks, notes, and other securities; their relative value and business customs governing them. Organization of corporations, railroads, street railways, manufacturing, and other industrial establishments. Duties of officers and responsibilities of same. Statistical and financial accounts; shop order system; office system; methods of employing men; elements of cost, depreciation, repairs, interest, taxes, and insurance. Rapid methods of manufacture; automatic machines and their relative value.

The course was continued under the name "Engineering Economy" and used almost the same description up to and including the catalog for 1919 when this course is listed for the last time.

Beginning with the catalog of 1913 we find the following reference books listed for the course in "Engineering Economy."

Gilbreth's "Motion Study"
Taylor's "Shop Management"
Church's "Expense Burden"
Church's "Production Factors."

In Dr. Alford's case there was no catalog file available and the following is wholly from memory:

I can add a bit of testimony to the early teaching of what we now refer to as Industrial Management. During the second term of my senior

year, that is the spring of 1896, Prof. W. W. Bird, who was then head of the Department of Mechanical Engineering at Worcester Polytechnic Institute, gave a short series of lectures on Management. I do not recall the title that he gave to these lectures, perhaps there was none. However, I remember distinctly their nature.

Prof. Bird, in addition to holding his teaching position, was an active manufacturer through family connections. Thus he brought to the students a first-hand knowledge of industrial operating problems. It was with these problems that he dealt in his short group of lectures.

It is quite likely that he may have been influenced by the work of Halsey and Taylor and others whose papers had just before that been published in the *Transactions of the A. S. M. E.* Whether that be true or not, these lectures by Prof. Bird properly belong in the background picture of the early attempts to teach Industrial Engineering in engineering schools.

From 1908 to our entry in the World War twelve schools began single courses as follows:

1908 Walter Rautenstrauch of Columbia Univ., Organization and Management, 30 students.

1909 Allan H. Willett of Carnegie Inst. of Tech.
——, Detroit Institute of Tech., Tool and Die Design.
C. H. Benjamin of Purdue Univ., ——

1910 C. F. Park of M. I. T., Industrial Management, 45 senior M.E.'s.

1912 E. O. Fitch of Lafayette, ——
C. W. Mixter of Yale Univ., Industrial Management, 12 students.

1913 W. W. Carlson of Kansas State Col., Factory Engineering and Factory Design.
——, Syracuse Univ., Industrial Engineering.

1914 C. P. Bliss and others of New York University, a group of options called Business and Engineering.
J. J. Wilmore of Alabama Polytechnic, Industrial Management.

1915 J. A. Bursley of University of Michigan.

At the end of 1918 two more schools began single courses: University of Akron and Northeastern University. It is useless however to go into these details. Like most of the foregoing, these courses were *generally* named and *miraculously* compounded. They did introduce seniors to something more than materials and I think they may have served some teachers similarly. At least there began to develop a small variety of industrial engineering options, then more definite units and sequences until a whole new field of professional activity emerged.

Full Course or Major Option

In my previous paper on this subject * I described how General Beaver of the Penn State board wanted M.E. taught "from the standpoint of manufacturing" and how he got Diemer's name from Taylor. This made Diemer in 1908 the first head of an Industrial Engineering department and the two men who were graduated in 1911, the first to hold degrees in the field.

The second school to offer a full program was Carnegie Institute of Technology starting with Prof. Willett as head, in 1910, and turning out eleven men in 1914; but Purdue starting her management options through L. W. Wallace as a service to M.E.'s in 1912, also produced graduates on the new basis in 1914, number unreported. The University of Washington at Seattle started a full program in the fall of 1912 and five men were thereby graduated in 1915. Next M. I. T. set up in 1914 not one but several sequences to meet the several needs of her older divisions and in 1917 graduated 17. Simultaneously New York University saw the opportunity, but there was a good deal of trial and error before she settled down in 1921 with J. W. Roe as head of an I.E. Dept. There was one graduate in 1919. It is said the first turn in enrollment came when five C.E.'s bolted that department to avoid a course in business law!

In 1915 Dexter S. Kimball returned to Cornell Univ., after a period in industry. He brought with him an industrial viewpoint which was resisted by others of the faculty, but the course he started turned out 75 men in 1920 and after ten years of missionary work the faculty swung to his view. In 1918 Walter Rautenstrauch of Columbia University and P. F. Walker of the University of Kansas, launched full courses. Columbia's was so full that it required six years; first graduates, 1925—1 B.S. and 5 M.S.

With war interruptions over in 1919, Fred E. Ayer, the new dean of the University of Akron, and ———————— of the University of Alabama, offered courses. In 1920 H. L. Seward was appointed chairman of a committee at Yale, to administer a course. This immediately became the "gentlemen's course" and graduated 45 the first year, 1923. Although called "Administrative Engineering," it was five-eighths mathematics, physics and engineering. I mention this to bring out the fact that here in the east leading educators from the beginning insisted, regardless of degrees or appellations, that the preponderance of curricula must be technical, that the graduates must be real engineers whatever else they might become in addition. In 1921, a depression

* Fifth International Management Congress, Amsterdam, July 1932 and *S. P. E. E. Journal* June 1932, pp. 806–839.

year, D. B. Prentice of Lafayette, and J. W. Hallock of the University of Pittsburgh, and ———————— of Virginia Poly. Inst. produced full courses. Thus before the Coolidge era of industrial prosperity we find the movement well started in the east, south, middle west and far west.

With the booming twenties, I.E. trained men came into real demand. The S. I. E. and the Management Division of the A. S. M. E. had survived despite the jokes on efficiency experts. An S. P. E. E. survey had shown that 2 out of every 3 engineering graduates, regardless of course, eventually went into some kind of management work. Through society conventions many professional papers were made public. A few magazines, wholly devoted to the field, flourished and in 1924 L. P. Alford brought out the Management's Handbook, which sold 30,000 copies in a few years. Other books became more specific, some definitely scientific and authoritative. Curricula committees began to get busy. They faced, as some still face, such problems as: how to offer the I.E. material without slighting the technical material which in itself was increasing; who should teach the courses; what texts would fit the needs; should they try to give all engineering seniors an I.E. service, or give fewer men a fuller sequence with separate degree, and if the latter, should these courses be put entirely in the senior year, or scattered through two or more years. The Wickenden report advised the service policy. A few followed. At New York University we dropped the separate degree, but kept most of the course. Now we are reversing again. The number (17) of schools starting full courses since 1922 requires a list, which follows:

1923 Montana State College
1924 Northeastern University
Oklahoma A. & M. College
1925 Syracuse University
1926 Lehigh University
Manhattan College
Ohio State University
1929 Alabama Polytechnic Institute
Iowa, State Univ. of
1931 Detroit Inst. of Tech.
North Carolina State College

At this time also Cornell University started its Adm. Eng. course in addition to its older I.E. This increased the management content to 31 per cent whereas the average for 18 schools had been 29 per cent.

1933 Florida, Univ. of
Rensselaer Poly. Inst.
1934 George School of Technology
Texas Tech. Col.
1935 Washington University, St. Louis
1936 Fenn College

In all 30 full courses.

Degrees

The degree for this work has varied about as much as the course content and I believe is the least standardized of any of the engineering degrees, and that means the situation is chaotic. All I can do in this paper is to group the schools according to the main degrees as follows:

3 B.S. and M.S.

Columbia, Pittsburgh, and Yale.

10 B.S. in I.E.

Alabama Polytechnic Institute
Alabama, University of (since 1937, changed from B.S. in Ind. Mgt.)
Detroit Institute of Tech. (for 4 yr. men)
Lehigh University
Montana State College
Northeastern (since 1931, changed from B. of Ad. Eng.)
Oklahoma A. & M. College
Penn State College
Texas Tech. College
Virginia Poly. Inst. (since 1929, changed from B.S. in Com.Eng.)

7 B. of I.E.

Akron, Univ. of (since 1927, changed from B.S. in Mfg.Prod.)
Detroit Inst. of Tech. (for 5 yr. men)
Florida, Univ. of (since 1936, changed from B.S. in I.E.)
Manhattan College (since ——, changed from B. of Eng.)
North Carolina State College (since 1939, changed from B.S. in Eng.)
Ohio State University
Rensselaer Poly. Inst.

9 B. of or B.S. in (as shown)

Carnegie Institute of Technology, B.S. in Mgt.Eng. (since 1936, changed from B.S. in Wks.Mgt. and that from B.S. in Com.Eng.)

Cornell University, B.S. in Adm.Eng. (extra since 1935)
Lafayette College, B.S. in Adm.Eng.
Mass. Inst. of Tech., B.S. in Eng.Adm.
Oregon State College, B.S. in Ind.Shop Adm.
Syracuse University, B.S. in Adm.Eng.
Utah, Univ. of, B.S. in Com.Eng.
Washington University (St. Louis), B.S. in Eng.Adm.
Washington, Univ. of (Seattle), B.S. in Com.Eng. (since 1930), changed from B.S.

8 B. or B.S. in M.E. or Other Engineering Field

Cornell University
Fenn College
Kansas State College
Kansas, Univ. of (since ——, changed from B.S. in I.E.)
Nebraska, Univ. of
New York University (since 1929, changed from B.S. in I.E.)
Purdue University
Rutgers University
Washington, State College of

and probably others who have made no claims to having any full line of I.E. work.

The Product

Most of us feel confident, except at examination time, as to the quality of our product. Certainly the I.E. graduates have suffered little from the depression and many have gone far despite it. But what of the quantity side? Let me first present another table.

School	Number of I.E. Graduates						Per Cent I.E. to All Eng. 1940 *
	'15	'20	'25	'30	'35	'40 *	
Northeastern Univ.			14	121	110	125	12
M.I.T.		48	94	59	74	60	10
Cornell Univ.		75	90	45	60	69	36
Ohio State Univ.				37	35	50	18
Penn State College	8	25	28	26	18	50	20
Lehigh Univ.				14	29	47	18
Yale Univ.			62	50	34	46	59
Carnegie Inst., Tech.	10	18	17	20	22	40	16⅔
Va. Poly. Inst.			7	15	33	35	15
Detroit Inst. of Tech.					28	35	5
Total						557	

* Data estimated by each school.

These ten schools are producing 69 per cent of the I.E.'s and the remaining 20 schools are graduating only 212 I.E.'s, or an average class of 11 each. The ratio of I.E.'s to all engineers looks even worse. The total I.E. graduates, 1940 estimate for all 30 schools, is 769, which is 12.6 per cent of their total engineering graduates. In other words, we are preparing 1 out of 8 of our engineering graduates for careers, 5 or 6 of which out of 8 are eventually I.E. in nature! Anticipating criticism I hasten to say that these figures are conservative since these 30 schools include a little less than half of all engineering graduates in the United States. On the other hand, my data are not 100 per cent complete. Harvard for instance, and some of the schools following the service-to-all-engineers policy, such as Rutgers, did not report any numerical data. A few other schools, such as the University of Texas and the University of Nebraska, offer a full 5th year in the College of Business Administration to some of their engineers, and others, as the University of Minnesota, offer a combination course of 2 years in the engineering college and 2 years in the School of Business Administration. Another group of schools, such as the University of Cincinnati, find that the "coöperative" experience to a limited extent prepares the men for management careers solely because "Coöps" get acquainted with labor and practical problems. None of these schools submitted any data for this survey. In fact my questionnaire did not solicit such data since it is almost impossible to get and if obtained could hardly be added in with the other kind.

The growth in number of I.E. graduates slowed down in percentage from 1920 to 1930, but since then has been improving slowly. The 1940 estimates are in fact very encouraging. See Table (for 30 sch.).

	Years					
	'15	'20	'25	'30	'35	'40 *
Nos. of I.E. graduates	23	175	400	463	563	769
Per cent of gains		660	129	15.8	21.6	36.6
No. of schools having grads.	3	6	17	20	25	30

* Data estimated by each school.

Conclusion

I have no right to take a "holier than thou" attitude, but as one member of a family speaking to other members of the family, I would like to start a little unrest. Many of us have been aware of certain I.E. shortcomings qualitatively. The data here submitted allow us to see them quantitatively. If Yale University can attract and hold 59 per cent of her engineering students in the I.E. field, why are 90 per cent of us getting only 20 per cent and under, or 50 per cent of us getting only 10 per cent and under?

If ten schools can have an average of 56 I.E. graduates, why must twenty schools stay down at an average of 11? Let us take steps to find what the successful schools have done and lose no time in capitalizing on their experience.

AN EXPERIMENT IN TEACHING METHODS FOR THE COURSE IN MATERIALS LABORATORY *

By CHESLEY J. POSEY

State University of Iowa

The present study was inspired by the work of J. S. Peck, as reported in his thesis "The Function of the Laboratory in Engineering Education" (Columbia University, 1936). While the writer believes that Dr. Peck has made a distinctly worth-while contribution by introducing the newer concepts of educational philosophy into the teaching of properties of engineering materials, he disagrees with him as to the extent to which changes should be made in the present system.

In 1932, before planning his experimental reorganization of the materials laboratory course, Dr. Peck collected information on the status of instruction in a number of engineering colleges. He obtained a picture that is familiar to us all. The usual scheme was to have squad experiments, with small groups of students performing experiments according to specific directions for the conduct of the tests and reporting of the results. The laboratory manual was in most cases written by the instructor in charge. The list of experiments varied from school to school, probably more because of differences in the background and interests of the instructor than because of differences in the equipment available. The objectives listed were more diverse, but almost all could be classified under one of three headings:

1. Acquisition of factual knowledge.
2. Drill or training in laboratory techniques.
3. Verification of the theories of the mechanics of materials.

In general, Dr. Peck's objections to the existing situation were that the student had little or no opportunity for participation in the more vital phases of the complete "unit of thinking" necessary for the solution of the laboratory problems. While the student's drill in following carefully detailed instructions might be effective in teaching him laboratory technique, and perhaps even some understanding of the theories of stress and strain, it could hardly

* Presented at the 47th Annual Meeting, S. P. E. E. (Mechanics), Pennsylvania State College, June 19–23, 1939.

be expected to enable him to develop the highly desirable concomitants of originality and judgment. The phases of the total problem calling for the exercise of these abilities had been preempted by the author of the laboratory manual.

In considering this part of Dr. Peck's work, it should be noted that the absence of any specific statement to the effect that the development of higher concomitants is an objective should not be taken to mean that this objective was overlooked, or entirely absent even if overlooked. The capable student learns much by example. He can admire a good laboratory manual. A poor one may stimulate him to think of possible improvements. It is no doubt true, however, that originality and judgment cannot be developed to the fullest extent by the methods which have been found to be efficient in achieving the other objectives.

Dr. Peck conducted experiments during two consecutive semesters at the College of the City of New York. They may be briefly described as follows. During each semester two control sections were taught by the standard method, using a laboratory manual. During the first semester an experimental section was conducted in such a manner that the students had to experience 100 per cent of the scale of thinking. They planned and executed their own experimental procedure, in order to solve problems which arose during class discussion on assigned topics.

At the end of the first semester the experimental group was found to be inferior to the control group on tests measuring attainment of knowledge of the manufacturing processes of structural materials, but superior to it on tests designed to measure the ability to solve new problems. For the second semester, two experimental groups were taught, but the method was changed from 100 per cent on the scale of thinking to about 75 per cent. The first period was given over to a demonstration, and during the remainder of the course there was more supervision by the instructor than there had been the first semester. At the end of the second semester the experimental group was found to be only slightly inferior to the control group on the tests to measure attainment of knowledge, and definitely superior on the tests of ability to solve new problems.

In planning a new laboratory manual for the course in properties of materials at the State University of Iowa, it was decided to introduce some work especially designed to allow the students to exercise their originality and judgment. It was not thought desirable to go as far as Dr. Peck did. Only a few of the students are really capable of doing satisfactory work on this level. Even for those who are, preliminary work is desirable. Numerous minor points of laboratory technique must be learned. Originality and judgment, as applied to laboratory work, need the support of a

fundamental knowledge of established skills and procedures if reliable results are to be secured.

The demands of the profession should also be considered. For every research worker, capable of planning and carrying out new projects, dozens of accurate transitmen, trustworthy inspectors, and reliable beam designers are needed. Men who can do these simple tasks, and do them well, are rare, and their services are in demand. Although they do not achieve great renown, their abilities command respect. There is a danger that in trying to train research workers we shall produce many who are incompetent and unhappy in routine jobs.

As finally reorganized, the course at Iowa includes two demonstration experiments, in which the instructor, while performing the tests, explains as many as possible of the fundamental laboratory techniques. These are followed by ten squad experiments of the standard variety, following definite instructions in the laboratory manual, after which there is a final experiment, planned by the members of the squad. The instructor purposely refrains from influencing the squad in its choice of subject for the last experiment, or expressing himself as to the value of various tests suggested. His function is to give advice sparingly, and to prevent the students from breaking any of the more valuable equipment. The time given for the laboratory course is three hours per week for one semester, so that there is ample time to complete all of the experiments and reports. Each squad is called on to present a fifteen-minute report on its final project to the entire class. No particular member of the squad is designated for this oral report by the instructor. To date there has never been any difficulty, the members of the squad seem to be able to settle this point without any violence.

The revised laboratory manual has been in use for three semesters, and the results have been gratifying. Some of the squads have performed surprisingly interesting experiments with reports suitable for publication in the school's technical magazine. Others, of course, have been very trifling. The instructor gives no grades on this experiment, and voices no opinion as to the relative merits of the reports. The class seems to sense that it is their affair, and upon several occasions has applauded after particularly good presentations.

The examination given in the laboratory course is designed to test the student's understanding of the laboratory experiments. We believe that it is an unusually good one for this purpose. In general, those students who are responsible for the good squad experiments make high grades on the examination; those who performed trifling experiments, or who merely "rode along" with better students in their squad, make low grades on the examination. The cor-

relation with the grades on the experiments performed according to specific directions, on the other hand, is very poor.

Dr. Peck thought that his second experiment introduced about the right amount of the new type of education. We have introduced far less, but believe it to be sufficient. We have been unable to run a controlled educational experiment, and have had to rely on subjective judgment as to the success of the work. It is to be hoped that others will give the idea a trial on a larger scale.

Acknowledgment is due Professors F. E. Holmes and J. W. Howe for their contributions in planning and carrying out the work. A copy of the directions for the squad-planned experiment is appended. The list of suggested projects is purposely kept small.

Experiment Directions

(From Laboratory Manual)

This experiment will be planned by the members of the squad. Two weeks before the experiment is to be performed, the squad shall discuss its choice of subject with the instructor. The following week, the squad shall submit, for approval by the instructor, a brief written outline of its plans, including a statement of the object of the experiment, a description of the procedure of testing, and a list of the items of data to be recorded.

Suggested subjects are given below. Choice is not restricted to projects on this list, however. The squad may wish to investigate further some unusual result obtained in one of the earlier experiments, or a problem arising in class or in some other course.

Strength and modulus of elasticity of special alloys.
Effect of heat treatment of steel.
Strength of welds.
Test of reinforced concrete beam.
Pull-out test of bond strength.
Strength of different kinds of wood.
Impact tests of plastics.
Variability of properties of supposedly identical specimens.

The report for this experiment shall be complete yet concise, of the type made by a testing engineer to a designing engineer. After the written reports have been completed, an oral report, not to exceed fifteen minutes, shall be presented before the class.

RESULTS OF ADMINISTERING STATE BOARD EXAMINATIONS TO SENIOR ENGINEERS*

By C. T. OLMSTED

Associate Professor of Engineering Mechanics, University of Michigan

Two years ago at Harvard I gave you some statistics about the performance of Michigan State Board examinees over a period of some fifteen years. Today I merely wish to repeat with a little more emphasis that part of my talk which had to do with the performance of one hundred and eight seniors of the University of Michigan who, during that period, took the first two days of the State Board examinations just previous to graduation. Such as they were, these examinations, I believe, could be considered as comprehensive tests of the more or less fundamental subjcts common to all students in the four-year engineering curriculum. In order to become a registered engineer, a candidate must eventually pass a three-day written examination with a general average of 70 per cent and with no grade on any part of the examination below 60 per cent. Seniors are not allowed to take the third day's examination which is more professional in character.

Fifty-nine of the seniors passed all subjects with grades of 60 per cent or better, the average being 79.5 per cent. The scholastic standing of these men for the four years in college was 85.6 per cent on the average. These results are certainly consistent and what was to be expected. However, thirteen men did considerably better on the examinations than they did in college, two of them being outstanding with general averages of 86 per cent and 90 per cent and both with scholastic standings of 75 per cent. On the other hand, a large number did much poorer on the examinations than was to be predicted from their college records, the following being typical examples:

Scholastic Record	Exam. Grade
83	67
87	72
97	76
98	80

The forty-nine seniors who failed one or more subjects with grades

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below 60 per cent performed more inconsistently. Their examination average was 61.4 per cent, while their average in college was 76.7 per cent. Only two of them did better on the examinations than they did in college and these differences were only a matter of 4 per cent and 1 per cent. Following are four cases in which the difference between the two grades was rather startling:

Scholastic Record	Exam. Grade
81	38
88	59
90	68
94	70

It seems to me that these results show a definite lack on the part of a large number of our graduates. Apparently the ability to attain passing grades semester by semester is not necessarily a guarantee that we have trained them to think in a logical manner, or perhaps I should say that they have trained themselves to think. Some final test is necessary before the final O.K. is given. Each part of the machine has been inspected and passed but we have neglected to find out whether the machine in its final assembly will work.

Last December I made a study of the results of Examination A, a four-hour general knowledge examination which is common to all candidates. I made up the examination myself and tried to find questions which I considered would be fair to all, regardless of age. There were six questions and the candidates were required to answer question one and any other four. Question one was given primarily to test the candidate's ability to express himself clearly in good English. The other five questions were problems in which the use of books of reference was permitted. Twenty-nine men took the examination of which number twenty-one were graduates of accredited colleges. Ten of the twenty-one received grades of 60 per cent or better and seven of these were 70 per cent or better. One non-graduate received a grade of 68 per cent while the rest, including two non-graduates, one senior, three graduates of non-accredited schools and one non-college man were below 60 per cent. The ten graduates of accredited colleges who had 60 per cent or better averaged exactly seven years since graduation, while the eleven who were below 60 per cent averaged 5.9 years since graduation, which merely shows that the type of this particular examination was apparently not such as to discriminate against the older men, a criticism which is constantly made by people who do not favor examinations.

Following is a tabulation of the results of the examination:

Question No.	Total No. Answering Question	Average Grade	No. of Graduates of Ac. Colleges Answering Question	Average Grade
1	29	58%	21	55%
2	23	45%	17	47%
3	24	78%	18	84%
4	15	44%	9	53%
5	29	60%	21	64%
6	19	33%	14	39%
Total Exam.	29	52%	21	56%

In Question (1) only one man was given full credit and he was a non-graduate. Two men were given flat zeros and both were graduates of accredited schools, one in 1936 and the other in 1924. One man with a Master's degree, 1935, from an accredited school was given 20 per cent.

In Question (4) none received full credit. Five received flat zeros, two of these being graduates of accredited schools, one of them being the holder of the Master's degree mentioned above.

One man who graduated from the University of Michigan in 1932 wrote to the Board after the examinations and severely criticized the examinations as being too academic. On this particular examination he received a grade of 60 per cent and on this problem he received 20 per cent, which I am not sure he deserved. On his sketch he had every passing lane occupied by two trucks, one going each way. I picked that problem out of a set of examinations given by the California Board as one which could not possibly be considered as academic and which did not require a knowledge of mathematics above elementary arithmetic. All it required was a fair amount of horse sense. Is it significant that only nine of the twenty-one graduates of accredited colleges chose to work that problem?

I cannot see any excuse for an engineering graduate getting less than 70 per cent at the very least on an examination of this sort. Hardened as you may be to poor results, I am sure you are a bit shocked at the fact that less than half passed 60 per cent or better and that the general average was only 56 per cent.

EXAMINATION "A"—ENGINEERS

Books of reference permitted. 4 hours.

Answer Question One and any other four questions.

1. There has been considerable discussion during the past three or four years as to whether or not a bridge should be built connecting the upper and lower peninsulas of Michigan. Write a short article on this subject,

discussing the engineering problems involved as well as any other questions which you think should be set forth in order that a logical conclusion upon the proposed project may be reached.

2. A tank contains 1000 cu. ft. of air at 60° F. under a gage pressure of 50 lbs. per sq. inch.
   (*a*) How many lbs. of air are in the tank?
   (*b*) How many B.t.u. will be required to heat the air in the tank to 120° F.?
   (*c*) What will be the gage pressure in the tank after the air is heated to 120° F.?

3. A 30,000 Kw. hydroelectric development cost $6,000,000. A steam plant of the same capacity cost $700,000.

	Hydroelectric	Steam
Interest on investment	7%	7%
Taxes	1%	1%
Annual operating costs	$40,000	$175,000
Annual maintenance	50,000	90,000
Annual depreciation	30,000	80,000

Cost of coal $2.50 per ton and one pound is consumed per kilowatt hour.

If both plants operate on an annual load factor of 50%, determine which produces the cheaper energy and how much cheaper.

4. Construction materials must be trucked from a railroad siding over a single lane road for a distance of 10 miles. There is room for only one truck to be loaded or unloaded at a time and it takes 15 minutes to load and 10 minutes to unload a truck. The truck speed, loaded or unloaded, is 10 miles per hour. Passing lanes must be provided at definite points along the road.
   (*a*) Determine how many trucks can be efficiently operated.
   (*b*) Will there be any advantage in operating the trucks in pairs?
   (*c*) Locate on a sketch the passing lanes in either case.
   (*d*) How many hours a day will the loading and the unloading crews be engaged if the trucks are operated singly as nearly eight hours each as possible, assuming that the drivers live at the loading end of the road?

5. In laying out some steel fabrication work, the following problem was encountered: Two triangles ABC and ACD have the side AC in common and the sides BC and AD cross each other. $AB = 12$ ft., $AC = 20$ ft., $CD = 4$ ft. Angle $ABC = 90°$, angle $BCD = 90°$. Find the length of AD to the nearest 0.01 ft. and the angles BAD and DAC to the nearest minute.

6. The population of a certain city was 20,000; 25,000; and 32,000 on Jan. 1, 1910, 1920, and 1930, respectively. It is suspected that the population curve is a parabola. If this is true, what was the population Jan. 1, 1900; and if the population continues to increase according to the same curve, what will it be Jan. 1, 1950? Develop the equation of the curve, using Jan. 1, 1900 as a starting point, and find the annual rate of increase on Jan. 1, 1928.

ENGINEERING HISTORY AND THE CULTURAL BACKGROUND *

By R. H. CAREY

Instructor in Mechanics and Materials of Construction, The Pennsylvania State College

The words culture and broadening have been used in connection with engineers many times. Recently, they have been used so often and with such abandon that their meaning has been distorted and confused to such an extent that it sometimes is dangerous to use them. "Culture" as defined means the act of improving or developing by education, the training or refining of the moral and intellectual nature. "Broad" from the same dictionary means main or essential, general as opposed to detailed or minute, extended in amount or range, extensive, comprehensive.

Several years ago I assisted in a small way on a study of engineering graduates and their present occupations. It was amazing to notice how many of them had not followed in the straight lines of their college curriculum. Numerous changes from one field of engineering to another leads to the belief that branches of engineering are not nearly so well-defined in practice as they are in curricula. It was from this observation that I decided upon the use of the word "broaden," although its meaning has been expanded to include more than this.

If we in engineering colleges are to train men to be aware of their responsibility as professional men, we must do more than develop technical skill, including theoretical and practical training. We must instill in them a just pride in the achievements already recorded in engineering history. We must instill in them not only the "how" but the "why" of engineering. What better way can we begin this than by a course in the historical background of engineering, since history is recognized as an essential in the education for a professional life? All professional fields have such histories, and the history of each profession is a cultural course that is basic to the completion of curriculum requirements.

How will a course in the history of engineering "broaden" the engineer's education?

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First.—It will identify the embryonic engineer with the traditions of his field. How necessary this may be is suggested by Richard S. Kirby and Philip G. Laurson, associate professors at Yale University, who preface their text, "The Early Years of Modern Civil Engineering," with these significant remarks:

> Civil engineering students, perhaps engineers generally, know little of the history of their profession or of the men of other days who have made it what it is.

To be more specific, let me quote from a case study of an engineer regarded by some of his acquaintances as "a man of inferior culture in view of his opportunities." The following statement from the case study of this man casts some reflection upon his engineering education. This quotation is from the book "Foundations of Curricula—Sociological Analyses" by David Snedden.

> In his profession (engineering) he is competent and well informed as to current engineering matters, but he has no curiosity as to the origins of the great inventions of his field. The names of Faraday, Ampere, Galvanni, and Kelvin mean little to him.

Second.—An important function of the study of the history of engineering is a broad view of the aspects and problems of engineering, taken from a genetic and developmental point of view. It should result in a series of understandings of the larger significant movements in human history as they relate to engineering.

To quote Ernst Mach, "Those who know the entire course of the development of science . . . judge more freely and more correctly the significance of any present scientific movement than those who, limited in their views to the age in which their own lives have been spent, contemplate merely the trend of intellectual events at the present moment."

Such a course might serve the purpose of an introductory prologue to research. Galileo's experiments with Aristotle's postulates illustrate the solution of certain problems by two distinctly different methods of approach, each method aiding more or less in the final solution.

Third.—An understanding of the historical background is a basis for a constructively critical attitude toward engineering as a profession. This is particularly true at this time when the forces of engineering are almost equally divided between the conservation and destruction of culture. It has been admitted that the world of today could not exist without engineering; but on the other hand, there is some question as to the possibility of continued existence with it. University City in Madrid, about to be completed at the outbreak of their Civil War, was conceived and con-

structed by engineering skill and destroyed by engineering science. The engineer as a leader has a responsibility in directing the application of his technical skill. Through history, he can see what men can do and he can see the patient work of certain engineers *destroyed* by wanton and selfish application of technical skill.

Fourth.—Although the engineer as a specialist finds it more and more difficult to keep informed on current progress in his particular field, he should be encouraged while in school in the practice of discrimination in his engineering reading. A part of his training should be a background course emphasizing the cultural aspects of engineering. An immediate result might be the development of a familiarity with libraries and their contents. Too often, engineers feel restricted to the engineering library, neglecting the general library.

Professor Ormondroyd at Michigan has been teaching some courses in the history of engineering mechanics and has been very successful. Last summer I had an opportunity to visit several of his graduate classes and, at that time, thought what an asset such a course would be for a sophomore or junior student in engineering. Such a course might be given concurrently with courses in mechanics, in order that Varignon's theorem would have a deeper significance than a proper noun for a well-established principle.

Jasper O. Draffin's paper presented before this Society two years ago illustrates in a remarkable manner the "Development of Some Concepts of Mechanics." E. W. Rettger's paper presented in 1927, "History of Mechanics Before Newton," would also be effectual in the personification of mechanics. A course in the history of engineering should, of course, be extended to more contemporary personalities. If personality is an asset to the teacher of engineering, personification should be an asset to the subject of engineering.

In presenting the material of a course in the history of engineering, we are interested in more than mere chronological continuity and more than a purely analytical account of the past. Our major objective is to provide a foundation with which to do clear thinking, for that ability is today more important than the mere mechanical manipulation of a century's accumulation of established facts.

Fifth.—Numerous papers, books, and opinions have been written recently, endeavoring to establish that an engineering education consists of a great deal of technical training and very little cultural training. Numerous attempts have been made to overcome this criticism by introducing into the curriculum courses in so-called cultural subjects. These courses are taught as a rule by the school

of liberal arts and not often by the engineering schools. On the other hand, numerous attempts to introduce such courses have met with failure because curricula are already overloaded and often it has been considered detrimental to the student's welfare to remove from his schedule any technical subjects.

In the evaluation of this so-called "cultural background," I believe most of the criticism originates when the engineering student attempts to speak or to write. Even though we have numerous required courses in English literature and English composition, it is often quite difficult to interest an engineering student in such courses. I might suggest that here may be an opportunity to broaden the engineer in two ways. Through recitations, a good instructor might be fortunate enough to help a student with diction and grammar and to aid in expanding his vocabulary. Recitations and papers presented in class would be another means of developing confidence in the student's own ability to express himself in some language other than the language of symbols.

I have noticed so often in the courses in mechanics and mathematics that the initial steps in development of formulæ and theories are lost because these steps have not been clearly expressed. There appears to be a great tendency on the part of engineers and mathematicians to jump immediately into the language of symbols without first expressing the idea in words. This particular fact has been proved to some extent by recent popular books concerned with science, such as "Mathematics for the Million" and "Science for the Citizen."

In this college, there have recently come to my attention several questionnaires which contained such questions as "Do you attempt to correct a student's use of English in your classes?" and "Do you attempt to grade a student on use or misuse of English?" To both of these questions, I would give a negative answer.

There are two reasons, I believe, why this is not done in engineering classes. First, the student considers it an injustice and second, the written and spoken words consist of phrases, parts of phrases, and disconnected words. Of course, the use of excellent diction and grammar will never be a substitute for the fundamental idea, but if the student possesses an adequate vocabulary and a satisfactory ability for verbal punctuation, he will be able to eliminate from his conversation such phrases as "See—see" or "You know." A skill in English will become more necessary as the engineer continues to exert an increasing political and social influence on the life of the nation. A history of engineering would consist almost entirely of reading, writing and speaking.

As a lever, why could we not use an engineer's interest in engineering to develop his written and spoken English at the same

time that we acquaint him with the traditions of engineering, stimulate appreciation of significant movements in history as they relate to engineering, and develop a professional attitude.

These five reasons for offering a course in the history of engineering are not reasons that are supplementary to an education, but things which are basic to an education, whether it is in the field of engineering or otherwise. Naturally, one added course such as a history of engineering will not provide everything, nor be a panacea for all our troubles; but it will assist us materially in reaching our ultimate objectives. It may assist us in meeting some criticism such as that from O. W. Eshbach, which appeared in the May JOURNAL.

> . . . I will venture my opinion that you are not primarily training students for industry but rather educating them for life, in which industry is one of their major environments. That is, the responsibility is to the boy, not us. His educational career, like his industrial experience, is continuing and the former only begins in college. In my opinion we are not expecting a complete education, but rather an alertness to change and an active expectation of continued preparation to meet new situations. If this is anywhere near accurate, the non-technical aspects of engineering education may not be overlooked. . . . If what I say may be construed as a criticism of what is being done, I should like that criticism to be directed at the lack of cultural objective commonly present in the uncoördinated studies now provided for as an excuse for cultural content.

This proposed course in the history of engineering should probably be given concurrently with or following courses in analytical mechanics or strength of materials. It should be taught in such a way that its coördination with engineering is definite and pronounced. At the same time, any history must include descriptions of trends and movements in human existence. A cultural objective would probably be more easily reached through the medium of such a course, than through several disconnected courses whose cultural effectiveness may be in doubt.

BASIC PHYSICS AS A PART OF MATHEMATICS *

By ALAN HAZELTINE

Professor of Physical Mathematics, Stevens Institute of Technology

By *basic physics* we shall signify that part of physical science which is directly based on observations, without the intermediary of hypotheses. It is the physics of gross matter, in contradistinction to atomic physics. It includes in increasing concentric circles the subjects of geometry, kinematics, mechanics, electricity and heat.

The program here offered for your consideration is the presentation of *all* basic physics to the student in the logical way that characterizes mathematics and is now customary in geometry: first, the clear and exact statements of the axioms; then the definitions of the appropriate physical concepts; and finally the deductions that follow from the axioms and the definitions.

The axioms embody certain fundamental observations of nature, chosen because they express common experiences and because they suffice to characterize the phenomena. Some of our fundamental observations are merely qualitative and lead only to descriptive concepts. Thus we observe that a body can be cut in two; and we call the common boundary a *surface.* We observe that a surface can be cut in two; and we call the common boundary a *line.* We observe that a line can be cut in two; and we call the common boundary a *point.* And finally we observe that a point cannot be subdivided; so we say that space is *three-dimensional.*

Most of our fundamental observations, however, involve the question of precision and can be made only in restricted ranges. We are then forced to *idealize* the phenomena; and our axioms apply strictly only to the ideals. Such limitation has caused axioms to be viewed as mere arbitrary postulates and to be chosen solely to facilitate mathematical development. This is unfortunate. The student later on will be expected to accept the deductions as *facts,* to be used in a real career in a real world. The axioms should express what he has observed (or, at least, can observe). For example (as was shown by John Wallis), the famous parallel postulate of Euclid is equivalent to the observation that bodies of different size can have the same shape; but the parallel postulate cannot be

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tested directly, while the existence of exact small-scale models and drawings is familiar to everyone. If observations involving astronomical distances are not consistent (that is, if physical space is slightly curved), we can confine the simple Euclidean geometry to the idealized conditions appearing on the earth and can base a non-Euclidean geometry appropriate to astronomy on more general axioms.

Some fundamental observations show the *invariance* of certain properties and lead directly to metrical concepts, called *physical quantities*. Of these, five may be recognized as fundamental: length, time, energy, electric current and temperature. Each of these concepts has to be built up by choosing an arbitrary value of the invariant property as a unit and showing how other values are expressed numerically in terms of this unit.

The concept of *length* can be built up from the observation that two bodies (called rigid), if brought into contact at two points on each, can be kept in contact at these points when the bodies are moved together in any way.

The concept of *time* can be built up from the observation that two idealized actions which start together and end together on one occasion will do so on any other occasion.

The concept of *energy* can be built up from the observation that, if two given motions require like expenditures from a given source, they will require like expenditures from any other source.

The concept of *electric current* can be built up from the observation that, if there is flow to or from a body only at its ends, the flow will be the same at any intermediate cross-section.

The concept of *temperature* (on the absolute thermodynamical scale) can be built up in the usual way from the observation embodied in the second law of thermodynamics.

The host of physical quantities derived from these five fundamental ones most often appear as *proportionality factors* under simple conditions and as *derivatives* under more general conditions. Thus velocity is the proportionality factor connecting distance with time when the motion of a body is uniform; and in general it is the time-derivative of distance. Force is the distance-derivative of energy. Mass is the proportionality factor connecting force with acceleration. (The constancy of mass under a wide variety of conditions—though not strictly under variable velocity—has caused it to be considered as a fundamental quantity, but this property merely makes it convenient as a *standard*, which is another matter.)

Some physical quantities appear as *products* under simple conditions and as *integrals* under more general conditions. Thus the area of a rectangle and the volume of a rectangular block are the products of lengths, while areas and volumes in general are integrals

of one length with respect to others. Dielectric flux is the time-integral of dielectric current; and magnetic flux-linkage is the time-integral of induced voltage.

How can we carry out the program sketched? The simplest way for me to answer is to describe briefly a course, entitled "Engineering Problems," given to Freshmen at Stevens.* Starting with kinematics, we immediately introduce the idea of a derivative by means of velocity, finding velocities as the slopes of distance-time graphs. Conversely, we introduce the idea of an integral as the distance equal to the area under the velocity-time graph. The arbitrary motion of an automobile along a given path is the first example. Next comes the notion of vector velocity, requiring a definition of the length of a curved path. Machines with link mechanisms illustrate the motions of rigid bodies, as do the sliding and rolling of cams and gear teeth.

Mechanics proper brings in energy, with force as its distance-derivative and power as its time-derivative. Then comes the notion of force as a vector. The same machines as were used in kinematics illustrate the force relations in rigid bodies, worked out in general by virtual velocities. Fluid mechanics brings in pressure and rate of flow. Solid and fluid friction are considered.

The two subdivisions of mechanics, elasticity and kinematics, are then taken up. In elasticity, we first discuss Hooke's law, giving the constant compliance of a spring, and then the deviations involving hysteresis, plasticity and rupture, all illustrated by stress-strain graphs. In kinetics, we first show that the proportionality of force to acceleration (leading to the definition of mass as the proportionality factor) is deducible from two observations: that the kinetic energy of a body depends only on the magnitude of its velocity; and that the distances, times and forces observed in any system of bodies do not depend on the velocity of the system relative to the observer. (Denial of the exactness of the latter leaves the door open for the special theory of relativity). The kinetic energy of a rigid body naturally brings in first and second moments of mass; and from it the force relations are derived by differentiation. Momentum is considered in connection with impact, as of bullets. The kinetics of fluids includes Bernoulli's principle and the impact of streams; the Venturi meter and the Pelton wheel provide examples.

Electricity follows mechanics. From electric current and power, we define voltage, the electrical analog of force. In con-

* This course is given in the Physics Department. I wish to acknowledge the coöperation of my colleagues in that Department, Assistant Professors John B. Hawkes and Edwin G. Schneider.

duction, involving electrical friction, Ohm's law states the proportionality between voltage and current in solid and liquid conductors, the proportionality factor being resistance. The space distribution of voltage and current is considered in uniform conductors, bringing in electric intensity, current density and resistivity.

The two subdivisions of electricity, electrostatics, which is electrical elasticity, and electromagnetism, which is electrical kinetics, are then taken up. In electrostatics, experiments are shown establishing the properties of dielectric flux, which is measured by the time-integral of dielectric current. When dielectric flux is proportional to voltage, we have capacitance as the proportionality factor, analogous to compliance. Dielectric absorption is a deviation having the nature of viscous hysteresis and is illustrated by flux density-electric intensity graphs analogous to stress-strain graphs. The more important formulas for mechanical forces in electrostatic fields are derived from dielectric energy relations.

In electromagnetism, experiments are shown establishing the properties of magnetic flux, which is measured by the time-integral of induced voltage. Magnetomotive force is defined from magnetic flux and energy; and permeance is the proportionality factor connecting magnetic flux and magnetomotive force in non-magnetic cores. Magnetization curves, again analogous to stress-strain graphs, exhibit varying permeability and hysteresis. Inductance expresses the magnetic reaction in an electric circuit and is the analog of mass. The more important formulas for mechanical forces in magnetic fields are derived from magnetic energy relations.

This completes the Freshman course. Heat, the remaining subject of basic physics, is taken up at the beginning of the Sophomore physics course from a similar point of view.

What are the reasons for this program? The primary reason is to keep together the physical and mathematical aspects of engineering problems. Their separation, as is customary, is artificial and unnecessary; it is detrimental to the student, two of whose greatest troubles lie in understanding the physical significance of mathematics and in applying mathematics to physical problems. The scientific method of which physicists are proud is best presented through the rigorous approach of mathematics; and mathematics teaching is greatly broadened by its extension to the many-dimensional concepts of physics. Moreover, the empirical functions of physics and engineering provide just the generality needed for introductory mathematical presentations. The vibrations of any point on a moving automobile suggest that at least its acceleration

is a non-differentiable function of time, unless we idealize the motion. Numerical and graphical methods of differentiating, integrating, and solving differential equations are the most fundamental and also the most easily grasped by the student, who should be given the point of view that it is only a happy accident when a function is expressible by a formula.

Another reason for this program is to satisfy the student's initial hopes and enthusiasm by at once introducing him to the languages in which an engineer thinks and talks. We should not tell a student that he must take two years in preparation for two years of engineering, but rather that he is to have *four years of engineering*. My program looks philosophical, perhaps, to us; but that aspect is not so conspicuous to the student: his practice is with engineering problems, not with theoretical derivations. His home exercises in mechanics are all on a certain steam engine; and those in electricity, on a certain motor. He finds out about their basic operations: the piston velocities, crank-pin forces and speed fluctuation of the engine—and even how much the piston is displaced by elastic yielding of the mechanism; the division of current and voltage among the turns of the motor armature, the magnetic flux necessary to induce the given voltage at the given speed, and the field magnetomotive force required to produce this flux —and even the charging current that flows from the armature conductors to the core. He discovers what is important and what is negligible in two typical machines.

SPECIALIZED CURRICULA IN MINERAL DRESSING*

By P. C. EMRATH

Associate Professor of Mining, University of Kentucky

A very good definition of the processes of mineral dressing has been offered, as including all those "sequential operations of severance and separation of desired from undesired constituents of mineral aggregates." An ore, or any other valuable mineral aggregate, is thus the raw material to which the dressing operations are applied, and the object is to produce from these raw materials products which can be marketed profitably, or which may be further treated for extraction of valuable ingredients. Very commonly, a dressing operation is the first stage in the recovery of a metal; quite often the fruits of the dressing operations are economically useful without further treatment. It may therefore be possible to fix quite definitely the point in an economic mineral sequence where the dressing operations begin, but it is not always easy to find where the dressing operations cease precisely, or become something else. The border line between mineral dressing and such accompanying sequential operations as smelting and refining, is often obscured by processing that is not one or another in an orthodox sense. Part of this argument is concerned with that point; that there is not any line which defines sharply the limits of the mineral dressing processes. Any technical graduate qualified for practice in the dressing of minerals should thoroughly understand this circumstance and be capable of using it to technical advantage. A proper analysis of any problem in mineral dressing begins with *why* and cannot be governed by set rules that are fixed in place by the subordinate answers to *how*.

Study of the mineral dressing processes is at present most commonly a part of the engineering curricula in mining and metallurgy. With few exceptions, rather extensive changes in these curricula have developed in recent years. Most of them present a kind of characteristic specialized focus upon certain curricular forms. This focus has developed from the characteristic forms that problems in the two professional fields have taken. The mining engineer's professional interests are becoming more and more

* Presented at the 47th Annual Meeting, S. P. E. E. (Mineral Technology), Pennsylvania State College, June 19–23, 1939.

centered on the physical and economic problems involved in the finding and working of leaner and less accessible ore deposits. Constantly, his problems are being further complicated by the development of new economic mineral materials, and the necessities for finding ways for working new kinds of mineral deposits profitably. The engineering curricula in mining are being extended into more highly specialized study in physics, mechanics, hydraulics, thermodynamics, geophysics, and economics. To the metallurgical engineer, the present is the threshold of the age of alloys. The engineering curricula in metallurgy are extending farther and farther into specialized study of the physical structure of the metals, with specialized emphasis on the fundamental sciences related to such study. The metallurgical engineer is specifically most interested in an ever-widening group of metals that compose his raw materials, and his preoccupation is drawing him farther from direct interest in the processes of original production of those metals. By and large, the changes in these engineering curricula have left out, or ineffectively included, comparative extensions in specialized study of the sciences concerned in the arts of mineral dressing. In many cases, the changes have also seriously diminished the amount of technical study devoted to the processes of mineral dressing, such as is commonly given in the form of laboratory work. We all understand that the technical schools, on the whole, were not the originators of technical specialization. In the large sense, they have been forced into it as an expedient to meet the demands for professional specialization, which was in turn an expedient growing from economic roots. Engineering is the application of the sciences to the economic, physical, and social problems of human beings. As the engineering practices extend into more and more extensive uses of the sciences, the scope of preparatory study in the technical schools that can be called "fundamental" increases accordingly. It has not been so many years since a technical school could offer a sound four-year training in the scientific fundaments of engineering practice that could enable a graduate to fit into any professional niche that he might encounter. That is no longer possible, and one of the principal reasons is that we still cling to the four-year course as a sort of educational standard, but it is no longer sufficient to contain more than the fundamental training in the sciences that is necessary to an introduction to one field of professional specialization. Mineral dressing is in every sense a form of engineering practice, and the fact is that an adequate training in its fundamentals can no longer be properly included in the modern engineering curricula in mining and metallurgy.

If the engineering curricula in mining and metallurgy, pursuing their own forms of specialized evolution, are not expanding their inclusions of mineral dressing studies adequately, the legitimate question arises; what of it? The modern metallurgical engineer, if the truth be told, looks upon the processes of mineral dressing as something like anachronisms. He is inclined to think in terms, for example, of the direct smelting of ores. He is preoccupied with the potentialities of that powerful tool the electric furnace. His nebulous convictions along those lines have been strengthened, it is true, by encouraging results in some cases. The mining engineer has become preoccupied with other matters, too, and is inclined to regard the problems of mineral dressing as the unfortunate lot of those queer fellows who cannot be stirred by the exhilarating heterogeneity of modern problems in mining. Between the two points of view, the dressing of minerals is in danger of falling into an unearned condition of obsolescence. This argument is in support of another point of view; that the dressing of minerals as a kind of engineering practice is withering of neglect in our technical schools, and unjustly so. The physical opportunities for the wider uses of the processes of mineral dressing are increasing rather than diminishing. In the order of processes producing finished mineral materials from the raw sources, mineral dressing is capable of assuming greater importance in the future than it has in the past. But, like other forms of engineering practice, mineral dressing must search farther into the ramifications of the fundamental sciences to meet the problems that are arising before it, and the logical place for this search to start is in the technical school. As a field of engineering specialization, the dressing of minerals presents great opportunities for valuable research, and it is a field in which the need is constantly growing for properly trained professional specialists.

Professionally, the field is actually at present very active, if not academically so. One is impressed by the fact that very little has been added to the dressing processes in recent years, other than largely refinements and improvements of processes already in use, and development of mechanical improvements in machines. But the principal problems of the whole field have not been met, on the whole, fairly and squarely. These principal problems are economic, which is to say, engineering, and are concerned fundamentally with applications of science, which is also engineering. The kind of engineering practice that we have defined as mineral dressing must in the future demonstrate that it is capable of meeting the economic problems that are arising as the list of economic mineral materials grows. To accomplish this, it is possible that some of the older

physical conceptions of the scope of the processes will have to give way, and exploration pushed into new physical and economic territory. In a scientific sense, it is quite possible that new and hitherto unused tools will find application if a wider field of fundamental study is opened to encourage their development. The dressing of minerals has been too long a field whose scientific principles have mostly been main strength and awkwardness. We have been tearing mineral aggregates apart for a long time with too little understanding of exactly how they are put together. Tearing them apart ruthlessly, too, with too little intelligent certainty that it was really necessary to the ultimate engineering purposes. We have had our complement of half-million-pound crushing machines, but perhaps too few petrographic microscopes, spectrometers, and too little scientific competence. Faint sparks have been struck here and there, it is true, but too often they have been fanned too feebly, or fallen on damp tinder. And too few of the sparks have shown through the windows of our technical schools. Some very great strides have been made, for example, in the development of more efficient flotation reagents. But the researcher is still looking for that ideal, the controllably selective one. And flotation is still a scientific problem child whose paternity is still not quite clear, and whose fidgety disposition is still troublesome. Some very fine work in the field of fine-grinding studies has been recently completed, as has some interesting work in the explosive shattering of minerals. Some recent developments in the use of dense-liquid separations have been very gratifying. The horizon that limited the applications of magnetic separation is lifting a little. The tight grip of sulfur on the iron in pyrite is relaxing a little, under the telling effects of some extremely intelligent dressing of the mineral. This thin list of things doing is encouraging, but not enough of them are happening in our technical schools. Specialized research supported by industrial organizations has been greatly responsible for them, and the work of individuals with courage and vision. The technical schools, on the whole, are not meeting the responsibilities that are primarily their own particular property. New responsibilities are developing, and responsibilities create opportunities. It is the business of the technical schools to train men to meet opportunities.

A STUDY OF THE ACTIVITIES OF GRADUATES OF THE SCHOOL OF MINES AND METALLURGY, UNIVERSITY OF MINNESOTA *

By E. H. COMSTOCK

Administrative Assistant and Head of School of Mines and Metallurgy

With the formation of the Institute of Technology at the University of Minnesota by the grouping together of the College of Engineering and Architecture, the School of Chemistry, and the School of Mines and Metallurgy, revision of the curricula in the latter unit became desirable so that the work of the freshman year for the various units might be made essentially uniform. This necessitated a re-adjustment of the work of the later years and resulted in a very comprehensive study of all phases of the various curricula. The professional activities of graduates was one of the studies carried on for the benefit of the faculty in their deliberations. For the purpose of this paper the information obtained at that time has been extended to include the class of 1938. The accompanying Table I gives activities of the living graduates of the School.

In the early days of the school but two degrees were offered, Engineer of Mines and Metallurgical Engineer. Before 1920 most of the students were candidates for the degree of Engineer of Mines. The course leading to this degree was broad. In addition to the usual mathematics, mechanics, chemistry, drawing, and physics, the course included plane and mine surveying with field work, geology, mining, metallurgy (including ore dressing and ore testing), design of wooden mine structures, hydraulics, and those principles of mechanical and electrical engineering necessary for the understanding of the operation of mining machinery. After the completion of this course of study, graduates were able to secure positions in various fields of engineering. Table II gives the activities of the living graduates who received the degree of Engineer of Mines.

The course leading to the degree of Metallurgical Engineer was so laid out that a student could select either ferrous or non-ferrous metallurgy as a field of specialization. The basic science preparation up to the end of the sophomore year was uniform for all students in the school.

* Presented at the 47th Annual Meeting, S. P. E. E. (Mineral Technology), Pennsylvania State College, June 19–23, 1939.

In the sophomore year all students took the course in general metallurgy followed by one covering the metallurgy of iron and steel. In the junior year courses in ore dressing, metallurgy of base and precious metals and metallography were required of all students in addition to mechanics, power plant, and a course in metallurgical plant equipment covering air compression, pumping, conveyors, Cottrell precipitators, etc. The principles of crushing and the details of ore-dressing machinery were covered in the course in ore dressing. In the senior year choice could be made between the

TABLE I

SUMMARY OF ACTIVITIES OF LIVING GRADUATES, SCHOOL OF MINES AND METALLURGY, UNIVERSITY OF MINNESOTA

		%
Responsible executive positions in large mining, metallurgical or petroleum companies		10.9
Subordinate positions in their chosen field		
Graduates 1938–1929	25.5	
1928–1919	12.4	
1918–1909	3.7	
1908–1899	1.1	
1898–1894	0.0	
	42.7	42.7
Government service in chosen field		5.8
Contractors		5.1
Civil Engineering		6.1
City, County or State engineering service		2.5
Consulting engineers		7.9
Sales of engineering equipment		2.6
Teaching engineering subjects		2.6
Graduate work in chosen field		0.8
Out of engineering		9.1
Lost sight of		2.1
Unemployed		1.0
Retired		.8

87 per cent definitely in Engineering.
67.1 per cent definitely in their chosen field.

ferrous or non-ferrous fields. Those selecting the ferrous field carried metallography, advanced metallurgy, electrometallurgy and selection could be made between special courses in metallography or those in ferrous metallurgy.

Those selecting the non-ferrous field carried advanced non-ferrous metallurgy, electrometallurgy, ore testing, and selection could be made between special problem courses in ore dressing or those in non-ferrous metallurgy. Tables III and IV give the activities of the living graduates who received the degree of Metallurgical Engineer.

TABLE II

SUMMARY OF ACTIVITIES OF LIVING GRADUATES HAVING THE DEGREE OF ENGINEER OF MINES

	%
Mining Executives	7.6
Metallurgy Executives	1.7
Petroleum Executives	1.4
Mining Engineers	30.3
Ferrous Metallurgy	2.1
Non-Ferrous Metallurgy	0.7
Ore Dressing	1.4
Petroleum Engineers	3.8
Geologist	1.0
U. S. B. M.	1.2
U. S. G. S.	.2
State Mining Bureaus	.2
Other U. S. Bureaus in chosen field	1.0
Contractors	6.7
Civil Engineering	12.2
Consulting Engineers	6.0
Sales Engineering Equipment	2.6
Teaching Engineering Subjects	2.6
Graduate Work	.5
Geophysics	.2
Chemical Engineering	.2
Out of Engineering	12.6
Lost sight of	1.2
Unemployed	1.0
Retired	1.4

TABLE III

SUMMARY OF ACTIVITIES OF LIVING GRADUATES HAVING THE DEGREE OF METALLURGICAL ENGINEER (FERROUS)

	%
Executives, Ferrous Met.	2.6
Research Ferrous Metallurgy	15.8
Research Aluminum	2.6
Research Vanadium	1.3
Ferrous Metallurgist	27.6
Metallography	21.1
Ore Dressing	2.6
Sales—Steel Products	2.6
Sales—Scientific Equipment	3.9
Civil Engineering	2.6
Graduate Work	1.3
Teaching Metallurgical Subjects	5.3
Out of Engineering	6.6
Lost Sight of	1.3
Unemployed	2.6

TABLE IV

SUMMARY OF ACTIVITIES OF LIVING GRADUATES HAVING THE DEGREE OF METALLURGICAL ENGINEER (NON-FERROUS)

	%
Executive Positions	10.3
Research Metallurgists	10.3
Metallurgical Engineers	7.7
Ore Dressing	20.5
Ferrous Metallurgists	2.6
Sales—Metallurgical Equipment	7.7
Mining	2.6
Civil Engineers	15.4
Construction Engineers	5.1
Chemist-Assayer	2.6
Out of Engineering	12.8
Lost Sight of	2.6

In 1911 a curriculum in geological engineering leading to the degree of Engineer of Mines in Geology, was adopted. This course was planned to give a man a thorough course in geology and, at the same time, the engineering viewpoint. To that end all candidates for this degree take the courses in mechanics, mining and ore dressing in addition to the various geological courses. The success of graduates from this course has been gratifying and has confirmed our idea that a geologist with an engineering training would fill a need in the industry. Table V gives the activities of the living graduates who received the degree of Engineer of Mines in Geology.

In 1937 a course in petroleum engineering leading to the degree of Engineer of Mines in Petroleum was first made available. The

TABLE V

SUMMARY OF ACTIVITIES OF LIVING GRADUATES HAVING THE DEGREE OF ENGINEER OF MINES (IN GEOOLGY)

	%
Executive Positions	10.8
Mining Geology	17.6
Petroleum Geology	20.3
Mining Engineering	8.0
Petroleum Engineering	2.7
Petroleum Production	4.1
U. S. G. S.	2.7
Geophysics	1.3
Natural Gas Engineering	1.3
Consulting Geologist	5.4
Civil Engineer	10.8
Teaching Geology	4.1
Graduate Work	4.1
Out of Engineering	6.7

need for such a course was brought to the attention of the faculty by many graduates in the petroleum industry. As one expressed it: "I am a production engineer. I am but a reformed geologist. I don't even know what makes a pump pump." The adoption of this curriculum came after a detailed study of the needs of the industry covering a period of about two years. Table VI gives the activities of the living graduates who received the degree of Engineer of Mines in Petroleum.

A study of these tables reveals the fact that the broader the field the more diversified are the activities of the graduates. Our experience in placing graduates indicates that, within certain limits, it is easier for the men with the broader training to secure a position, especially in times of depression in the industry.

TABLE VI

SUMMARY OF ACTIVITIES OF LIVING GRADUATES HAVING THE DEGREE OF ENGINEER OF MINES (IN PETROLEUM)

	%
Executive Positions	11.5
Production Engineer	34.6
Petroleum Engineer	7.7
Petroleum Geophysics	7.7
Petroleum Geologist	11.5
Petroleum Sales	7.7
Out of Engineering	19.2

In order to secure and hold a position a graduate usually starts work on some routine "craft" job, such as surveying, assaying, chemical analysis, logging oil well formations, photomicroscopy, or sampling, to mention but a few of the various possibilities. We are sending a graduate of this year's class to run a plane table for one of the seismographic crews of a large oil company. He knows how to run a plane table and is careful and accurate in everything he does. I know he will make good and be in line for something better before long. Let us suppose that when he reported for work he stated to the chief that he had had a thorough grounding in the fundamentals of mathematics, physics, and chemistry, had an understanding of the theoretical technology of the engineering field and, while he knew the theory of the plane table he had never seen or used one, in fact, had been told that in case he ever should be required to use one he would be instructed in the field by his employer. The college in which he was prepared believed that it was a waste of time to acquire a skill which might never be used. I am afraid that we would never again be asked by that company to supply a plane table operator.

We believe that a mining engineer earns much of the engineering viewpoint by being obliged to close a traverse where every reading depends upon his accuracy in manipulating the instrument and where accuracy in computation is a prime requisite.

We believe that an ore-dressing engineer learns much of the engineering viewpoint by being obliged to carry to completion tests of ores where accurate sampling, accurate analyses of the original ore and of the various products of the treatment, together with accurate computation, are prime requisites to a balance between metal in the original ore and recovery in the heads and loss in the tails. In case lady luck deals him a job where he never has to run an instrument or test an ore he at least has had instilled in him a realization of the need for accuracy in manipulation, and in calculation, a realization which no amount of lecturing on the part of an instructor could produce.

The graduates who enter large industrial organizations maintaining training courses may not need to acquire the ability to carry on a "craft" job, but very few of the companies employing the products of our mining schools maintain such courses.

In a recent "bull session" with a notable in the mining industry, he advocated a course dealing exclusively with basic science. He was asked what his first job after graduation was. He replied "surveying." He was asked where he learned surveying. His reply was "in college." He was then asked what would happen to an engineering graduate hired by one of his companies for an engineering position who could not run an instrument. He guessed "he would be fired." I am inclined to believe that his guess was right.

From our experience gained by watching the progress of our graduates, by studying the requirements set forth in requests to recommend graduates, and by talking to representatives from various companies coming to interview prospective graduates, we are convinced that the ability to carry on a "craft" job is a requisite to securing a first position. Securing a position is the first step toward success and the second step toward success consists in attracting attention to oneself by "delivering the goods" in this first position.

CIVIL ENGINEERING PAGE

Notes of interest for members of the Civil Engineering Division.
—Editor, EDWARD E. BAUER, *University of Illinois, Urbana*

M. W. FURR, *Chairman*
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CONFERENCE ON SOIL MECHANICS AND ITS APPLICATIONS AT PURDUE UNIVERSITY, WEST LAFAYETTE, INDIANA, SEPTEMBER 2–6, 1940

Sponsored by: Committee on Foundations and Soil Mechanics, Civil Engineering Division of the Society for the Promotion of Engineering Education, and the School of Civil Engineering and Engineering Extension Department of Purdue University.

Purpose: Approximately fifty engineering schools in the United States and Canada now offer courses in Soil Mechanics or include extensive material on Soil Mechanics and Soil Testing in courses in Foundation or Highway Engineering or both. Since the meetings of the First International Conference on Soil Mechanics and Foundation Engineering in 1936 there have been persistent requests from teachers and administrators of Civil Engineering for the organization of a Conference on Soil Mechanics and Foundation Engineering by the Society for the Promotion of Engineering Education. These requests have suggested that the Conference consider the following problems:

(1) The material which should be included in a course or courses in Soil Mechanics.

(2) The place of such courses in the Civil Engineering curriculum and their relation to courses in Foundation and Highway Engineering.

(3) The amount and type of laboratory practice which should be included in such courses.

(4) The equipment necessary for an adequate instructional laboratory.

(5) The methods whereby such courses can be taught by instructors who have not had the opportunity to take formal courses in Soil Mechanics.

(6) Bibliographies and sources of reliable information on the various phases of Soil Mechanics.

(7) Possible requirements in regard to courses in Soil Mechanics in the Civil Engineering curricula which may be imposed by future accrediting committees of the Engineers' Council for Professional Development.

In response to these requests this Conference has been organized. Its purpose is to provide:

(1) Opportunities for the discussion of the problems incident to the presentation of courses in Soil Mechanics.

(2) Assistance toward individual solutions of these problems by means of assembled data and experience.

(3) Authoritative discussions of basic subject matter in Soil Mechanics.

(4) Sources of reliable information on Soil Mechanics problems and criteria for the evaluation of new material as it becomes available.

To achieve this purpose for a subject as new and frequently misunderstood as Soil Mechanics it is necessary to emphasize the scope and content of the subject, the physical laws which govern soil action, and the limitations imposed by lack of homogeneity of soils in nature and incomplete understanding of soil properties. To this end a preliminary program has been prepared which covers fundamental aspects of our present knowledge of important fields in Soil Mechanics and attempts to coördinate the entire subject matter. A large group of recognized authorities has agreed to prepare papers which stress basic problems.

A preliminary program has been issued, which indicates a division of the subject matter into the following sections:

Section I—The Scope of Soil Mechanics and Soil Mechanics Instruction.
Section II—Underground Exploration, Sampling, Identification, and Classification of Soils.
Section III—The Physical Properties of Soils and Their Determination.
Section IV—The Mechanics of Rupture in Soils.
Section V—The Mechanics of Deformation in Soils.
Section VI—Soil Mechanics Applied to Highway Engineering.
Section VII—Laboratory Equipment, Technique, and Demonstrations.

Proceedings: The Proceedings of this Conference, consisting of papers listed in the preliminary program, with such additions as the committee may accept, will be published and distributed to members of the Conference in advance of the meetings. It will be expected that those attending the meetings will have made themselves familiar with these Proceedings in order that all may enter immediately into discussions on each subject.

Bibliographies: Each contributor to the Proceedings will be requested to submit a selected bibliography on the subject of his paper. Where possible, additional bibliographies will be included in the Proceedings covering subjects not discussed by papers.

Housing: Living accommodations and meals for members of the Conference will be provided in Cary Halls, Purdue's beautiful new residence halls for men. It is expected that the cost of room and meals from 4 P.M. Sunday afternoon, September 1st, to 10 A.M. Friday morning, September 6th, will not exceed $13.00 per person for those who register in advance of the meetings.

Participation in the Conference: All members of the Society for the Promotion of Engineering Education, all persons interested in the teaching of Soil Mechanics, Soil Testing, or their applications, and all engineers interested in any phase of Soil Mechanics are cordially invited to become members of the Conference and to attend the meetings.

Registration Fee for Purchase of Proceedings: To meet partially the cost of publication of the Proceedings which will be distributed in advance of the meetings, a registration fee of four dollars will be required before the Proceedings can be mailed. Those who may wish to attend the meetings without obtaining the Proceedings need pay no fee, but must register in advance to reserve room and meals in Cary Halls. Proceedings may be purchased by those who find it impossible to attend the meetings at the cost of publication, probably between four and five dollars. Further details in regard to registration, the final program, the content and dates of shipment of the Proceedings will be announced later.

Address all communications concerning the conference to Professor P. C. Rutledge, Purdue University, Lafayette (or West Lafayette), Indiana.

ENGINEERING ECONOMY NOTES

Engineering economy is that phase of engineering work in which technical plans and operations meet the critical and constructive tests of applied economics.

EDMUND D. AYRES, The University of Wisconsin, *Editor*

UNAMORTIZED VALUES IN REPLACEMENT STUDIES

Mr. De Garmo's article on this page in the September issue should not go unchallenged. There are two approaches to replacement studies: an accounting approach and a managerial. If we assume that Mr. De Garmo used the accounting approach, his paper contains an assortment of minor errors. If we assume that he used the managerial approach, his discussion is permeated by a fundamental error.

The Accounting Approach

The accounting approach assumes that the annual cost of operating the old equipment would continue unchanged if the replacement is not made. This cost includes the usual accounting charge for depreciation. The annual operating cost of the proposed new equipment is estimated on a comparable basis. Depreciation of the new equipment will, of course, be estimated and included. At this point Mr. De Garmo suggests that the new also be charged with an amount equal to the depreciation charge on the old equipment in order to amortize the remaining book value of the old. This is correct and proper. If the usual and regular depreciation charge on the old equipment is continued as a charge against the old, a charge should be assessed against the new to finish the amortization of the old. In the final comparison of new and old, the two charges cancel. This is clearly shown in Mr. Freeman's article in the March issue.

If the replacement is made, the unamortized cost, as a matter of bookkeeping, should be written off against the surplus. It represents a mistake in the old amortization rate which has resulted in the overstatement of profits during the life of the equipment. Such profits have been closed to the surplus account, which thus becomes overstated. Mr. De Garmo suggests a second and incorrect ac-

counting method which he alleges is particularly appropriate to small companies.

Mr. De Garmo neglects the decline in the resale value of the old equipment. Mr. Freeman gives this factor its proper weight in the formulas he develops in the March issue.

Mr. De Garmo insists that past obsolescence costs must be absorbed either by the increased profits produced by the new equipment, or by the business generally. Neither view is true. If the owners anticipate future profitable operations, they may make good capital losses by subscribing to additional stock, or by borrowing additional funds. In any event, the loss is past and can no longer be avoided. Continuing to confuse future planning with the unavoidable past is suspiciously like crying over spilt milk.

The Managerial Approach

Accounting is concerned with the past, which can no longer be influenced. Management and engineering economy are concerned with the future, which is still subject to some degree of control. Bookkeeping profits, incomes and expenses are necessary for calculating tax payments and determining the legality of dividends. For many other managerial purposes, particularly for solving problems of engineering economy, they are a snare and a delusion for the uncritical. They mislead by continuing to report sunk costs, that is, irretrievable investments. Those trained in economics and management can make use of the historical accounting data by selecting pertinent data, rejecting irrelevancies, and making proper adjustments for changed conditions or plans. Then historical data become a valuable basis for predicting future events. Such data must not be substituted for, nor confused with, the predictions.

From this forward-looking point of view, the old equipment is not charged with depreciation, merely with the annual decline in resale value. The new equipment, not yet purchased, is charged with its estimated depreciation, but not with the amortization of the remaining book value of the old. The book value of the old is entirely ignored as a fiction of accounting convenience. The two alternate solutions to the replacement problem are clearly delineated and differences in costs sought. The problem is settled in terms of such cost differences.

Mr. De Garmo's suggestion that unamortized values are a good index of future obsolescence indicates that he may have been thinking in terms of the managerial rather than the accounting approach. In any event, the suggestion cannot be entertained. Assume two companies possessing similar machines; one old, worn-out and

written down; the other new, in prime condition and carried at full original cost. Surely the probable cost of obsolescence of the newly invented equipment is not simultaneously zero and the full first value.

When should a cost figure in an economy study? The test is simple. Does it change future cash receipts or expenditures in any way? The owners of a business are primarily interested in its ability to pay them as much cash as possible. The amount paid to the owners in the past is no longer subject to change. The amount which can be paid in the future depends upon three factors only: (1) the cash now on hand, (2) future cash receipts and (3) future cash disbursements. Any factors which do not affect any of these three items should not be considered in an economy study.

Mr. De Garmo says the first two questions asked are: "(1) What *will be* the return on the *required* investment under the *assumed* conditions? and (2) How long *will it take* for the equipment to pay for itself so that no loss will be incurred in case conditions change?" As shown by my italics, these questions are forward-looking. They do not run in terms of what accounting records report has formerly been true. They call for estimates of incomes and costs, of investments, of conditions, and of future durations. Accounting data must be used as a basis for prediction, not as a substitute therefor.

Mr. De Garmo objects to the inclusion of interest as a cost. This is in agreement with almost universal accounting dictum and at variance with universal economic logic. Yet it is always included in practical cases. When explicitly included as a cost, management asks, "Is there any additional return on investment?" When it is excluded, management asks, "Is the return on investment here in excess of the interest we could obtain elsewhere?"

Most of this is adequately covered in the price theory section of any elementary economics text: sunk costs, fixed costs, overhead costs, differential costs, opportunity costs and interest. For an extended and excellent treatment of the whole question see J. M. Clark's "Economics of Overhead Costs" or E. L. Grant's "Principles of Engineering Economy." Clark's volume is stronger and broader on the theory; Grant's stronger and more specific on the application.

BILLY E. GOETZ,
Armour Institute of Technology.

ENGLISH NOTES

DEVOTED TO THE INTERESTS OF TEACHERS
OF ENGLISH IN ENGINEERING SCHOOLS

J. L. VAUGHAN, *Editor*, University of Virginia

CHAPTER VIII: CONCLUSIONS AND RECOMMENDATIONS *

By H. P. HAMMOND

Dean, School of Engineering, The Pennsylvania State College

Preceding chapters of this report deal with the function of the department of English in the school of engineering; the teaching of composition, literature, and speech; the selection and training of teachers; the organization of the English department and conditions surrounding its work; and variants on methods commonly employed in English instruction.† Each of these chapters comprises summaries of fact and opinion. The purpose of the present chapter is to review some of the salient points of these summaries and to present the recommendations of the committee in charge of the study.

It is scarcely necessary to say that the committee disavows any attempt at finality in this report. Not only have the problems of the teaching of English engaged the attention of many of the leaders in engineering education for a long period, but every aspect of the subject will continue to require the best study that can be brought to bear upon it. It is our hope, rather, to contribute to this process of evaluation and remedy, and to present the constructive conclusions that may be drawn from the opinions of those who have been consulted.

* This is Chapter VIII of the Report on Instruction in English in Engineering Colleges.

† JOURNAL OF ENGINEERING EDUCATION, Vol. XXIX, Chap. I, No. 7, p. 549; Chap. II, No. 8, p. 626; Chap. III, No. 9, p. 758; Chap. IV, No. 10, p. 937; Vol. XXX, Chap. V, No. 3, p. 300; Chap. VI, No. 4, p. 408; Chap. VII, No. 7, p. 608.

Summary of Opinions

Of fundamental importance is the conviction, now held almost universally, that adequate training in English is vital in the collegiate education of the engineer if he is to take his proper place in professional and public life. This was not always so, but now we may repeat—"The battle of the place of English in engineering education has been fought and won." We may therefore pass on to the problems of making literate engineers of the students who enter engineering colleges with all the defects of education and background that the secondary schools have been unable to remedy among the numerous and heterogeneous student populations with which they have to deal.

This is indeed a monumental task, and it would not be surprising if results fell short of expectation. With all due allowance for the inherent difficulties, however, a great many thoughtful observers believe that better results could be and should be achieved. Criticisms of instruction in English have even greater force when they come, as many of them do, from graduates who have become conscious of their deficiencies. The committee believes that these criticisms are essentially valid and that schools of engineering, by and large, are not producing among their graduates the level of literacy properly to be expected of them.

It is also agreed by a majority of those who expressed themselves that all of the three common forms of instruction should be provided: composition, literature, and speech. Although it is commonly believed that the level of preparation of entering students is such as to make drill in the elements of grammar and punctuation and the building up of vocabularies essential, the objectives of English courses should not be confined to this purpose. A major aim is the development of ability to arrange a process of thought in systematic and logical form and to express it clearly and concisely.

It is noted, also, that there is a good deal of insistence on the part of graduates, and particularly of older graduates, that their greatest lack in ability to express themselves properly is in oral rather than written English.

The committee's inquiries brought forth fewer spontaneous comments than might have been anticipated as to the quantitative provisions for English in the curriculum. Although the significance of this might be misinterpreted, it seems reasonably clear that it is the quality of instruction rather than its quantity that is most seriously questioned. It should be noted in this connection, however, that provisions for English are very uneven among engineering colleges. In a considerable number of them these provisions should be substantially increased in order to provide adequately for the three types of instruction just mentioned.

A number of correspondents raised the question of the disposition of the time allotment for English. There is a growing belief that some portion at least of this time should be reserved for the later years of the curriculum, when the greater maturity of the students as well as the greater degree of spontaneous interest that has been observed among upper classmen will yield correspondingly more effective and more lasting results.

It is also evident that courses in English are too often limited to a mere drill course in composition, to the neglect of the vital opportunities that may be realized from the study of the masterpieces of English literature. It is doubtless true that our writing habits are formed in considerable measure by what we read, just as we learn to speak from what we hear.

Many voice the opinion that it is only through the active support and coöperation of their engineer colleagues that the efforts of teachers of English may be made effective. With this view the committee is in full accord. As a corollary, it is evident that there exists a problem of faculty as well as of student improvement in English usage. Until the great body of engineering teachers are themselves proficient in English it is hopeless to expect students to continue to observe good standards after the English department has taught them all it can.

Conditions Favorable to Good Work in English

The Teacher

Good teachers are the *sine qua non* of good teaching. While everyone will agree with this axiomatic statement, its full significance in relation to the teaching of English to engineering students may not be so clearly evident. For one thing, the problem we are here considering is probably the most difficult of all those encountered in the school of engineering. It is not merely a matter of starting from zero to build up a proficiency that is difficult at best to establish, but in many cases of starting from below zero because it is necessary to eradicate deeply ingrained faults, inculcated in home and community backgrounds. Moreover, it is necessary to deal with students whose interests are pretty firmly fixed on definite vocational aims to which, as they conceive them, the relationship of English is not evident. Furthermore, the teacher of English is thrown on his own resources to a greater degree than are most of his colleagues in science or engineering. By the nature of his work, the textbook—that safe support of mediocre teaching—is but an incidental aid to his work rather than its essential basis. Because of the relatively high degree of personal relationship that

should always obtain, and often does, he must possess unusually high qualities of leadership as well as of ability to interest and to inspire his students. In a word (an old-fashioned and often misunderstood and abused one), the teaching of English is to a great extent a matter of pedagogy; and great pedagogues are rare in the land!

The quality of a teaching staff depends directly, of course, upon the care and skill with which it is chosen. We would say, therefore, and with some emphasis, that the college administrator who complains of the work of his English staff might, in many cases, look to himself in the first instance as the one responsible for its selection and for the conditions under which it works. On the other hand in no other field of instruction is it more difficult to choose young teachers who may be expected to develop the special qualities that the nature of their work requires.

Many of the criteria of selection that serve usefully in other fields are not equally helpful in selecting teachers of English. The Ph.D. degree, for example, which is so often insisted upon in liberal arts faculties, by no means insures that its holder is competent to teach composition to sections of engineers. Success in that work depends on ability to judge accurately and to deal astutely with students whose major interests lie elsewhere fully as much as it depends on scholarly attainment in advanced phases of English literature, important as that may be in other situations. Difficulties of attracting good men are due in large measure, also, to the fact that the position offered is often limited to the teaching of elementary courses in composition and provides little or no opportunity for the satisfaction of those professional ambitions that are likely to have been developed by advanced specialized study in the graduate school.

This limitation to the teaching of English in engineering schools is, indeed, a matter of major concern, for unless means can be found to accord the teacher recognition commensurate with the importance of his professional work, strong staffs cannot be held together even if they can be once assembled. To this we would add that compensation of teachers of English should be on the same scale as that of teachers of engineering of comparable faculty rank, and there should be about the same distribution by ranks as obtains in other divisions of the faculty. In the long run, a staff is likely to be no better, in comparison with other staffs, than its rate of compensation is in comparison with theirs. It is unfortunate that in many instances the pressure to secure competent men for specialized engineering teaching has obscured the equally vital necessity of securing good men for English. In each English staff there should be at least one really first-class man whose leadership will

raise the level of the entire group, whose views will be respected by his engineering colleagues, and whose qualifications will tend to set the standard when new men are chosen. Such a man should be compensated at the maximum rate which the school affords.

According to the evidence and opinions supplied by correspondents, the particular type of educational program that teachers of English have followed in preparing for their careers is not so important as is sometimes asserted. There are too many instances of strong staffs comprising individuals having various educational backgrounds, to support the idea that teachers of English to engineers must have received any one kind of preparatory training. This applies in particular to the contention that such teachers should be engineering graduates. True, they should have acquired an understanding of and a sympathetic attitude toward engineering students and they should have such a general conception and appreciation of the world of science and technology as any broadly educated man should have. What is required is good teachers; everything else is secondary. If those who teach engineers are really good teachers, they will soon develop the points of view and the attitudes that will make for success with their particular student groups.

There is, however, one very important point concerning the preparation of teachers of English that must be raised: the neglect that prevails in graduate schools of systematic preparation of their students for the teaching of composition. Many who pursue advanced courses in English are destined to make the teaching of composition an important part of their future careers, and some of them will make it their life work. Yet neither graduate schools of liberal arts nor graduate schools of education make preparation for such work an element of any significance in their programs. This is a lack that deserves widespread attention.

Finally, it is essential that teachers of English should not be required to carry unreasonable teaching schedules, either in number of class hours or in number of students. Teaching loads should be such that ample provision may be made outside of class periods for conferences with individual students. We are convinced that there should be a reversal in the allotment of time for class work and for conference work respectively, for the latter is by far the more effective teaching procedure. It is not only more effective in training students in the organization and presentation of thoughts; it is also very much more effective as a means of correcting faults in writing and speaking. At present the conference is usually regarded as a subordinate adjunct of class recitations. We believe that the emphasis should be reversed.

Objectives of Instruction in English

To the foregoing observations concerning the teacher as a factor in providing conditions favorable to good instruction in English, we would add the necessity of setting clear objectives of the teaching program. These objectives should be formulated in terms of the knowledge and skills that the student is expected to achieve and the motivation he is to receive to further independent reading and study. In many instances, we feel safe in saying, the objectives of a program of instruction in English have been conceived of merely in terms of conventional courses of study to be taken and of the number of credits to be earned. They have not been arrived at as a result of a thoroughgoing analysis of the basic factors involved in the institution, its environment, its clientele, and the scope and requirements of engineering practice. Such an analysis is needed, not only in setting curriculum allowances—which should, of course, be adequate—but also in setting the specific objectives of each course and of the program as a whole in its relationship to the rest of the curriculum. We would emphasize that work in English should be planned as a *program* leading to specific objectives and adapted to the needs, interests, and abilities of students. It should be formulated just as the major sequences of courses in engineering are planned, rather than as a mere group of courses of traditional content arranged in a series based upon an assumption—largely unwarranted—of specified "prerequisites."

Coöperation of the Engineering Faculty

For good results in English, it cannot be said too often that the active support and coöperation of the engineering staffs are indispensable. This is something more than a general endorsement of English by engineering teachers; it requires their insistence at all times that their students shall continue without backsliding to write and speak according to the standards which the English staffs have established. The price for keeping students up to a given level of achievement in any field of study, and especially in English, where former habits are so likely to crop out at any time, is eternal vigilance. The English staff which deals with the student for a relatively small fraction of the time cannot do this; it is a duty that the entire engineering staff must assume. It is not enough to examine written work for grammar, spelling, and punctuation, although this is certainly important; the student should be shown how he might have organized his thoughts more logically and expressed them more clearly and concisely. In other words, the teacher of engineering should continue to teach the student the fundamental processes of thought and expression. These are vital

to success in any engineering course, and are just as much a part of it as they are of courses in English. The teacher of engineering cannot escape this responsibility; it is as much a part of his work as it is to see that the student learns to think logically on scientific matters by deriving formulas; both are forms of training in processes of clear, logical thinking and of expressing the results of such thinking, one being in words and the other in symbols. Sloppiness in either of these is indicative of sloppiness in the other; and tolerating sloppiness in either is indicative of low teaching standards.

Finally, in order to establish and maintain good work in English the effective support of the college administration is necessary at all times. In the situation surrounding instruction in English nothing is more necessary to the maintenance of morale than is the knowledge that the administrative officers and department heads are giving the English staff their support and coöperation, that they are ready to consult with their colleagues in English, and that they consider English a thoroughly integrated part of the program of engineering education. Administrative support means also willingness to provide the necessary accessories of English instruction in the same measure that laboratories are provided as accessories in engineering.

Development of Teachers

In addition to the maintenance of favorable surrounding circumstances, we believe that the cause of English instruction in our schools of engineering will be promoted by experimentation, just as engineering education at large has benefited by the trial of variants on conventional methods. An inquiry as to such experiments, made as a part of this committee's work, has disclosed a number of examples of the adoption of departures from conventional procedures. A preceding chapter of this report describes several of these. Most of them are concerned with types of courses or unique methods of instruction, in other words with the work of the teacher; none deals specifically with the other phase of the problem—the development of the teacher himself.

Herein, we feel, lies a great need and opportunity. We believe that the time is ripe for the inauguration of specific means for developing teachers of English both on an institutional and on a regional or national basis. To that end we advocate the trial establishment in a few representative institutions of definite plans, under carefully controlled conditions, for the study of teaching procedures by groups of younger teachers under the guidance of skilled and inspiring older members of the staff. Study should be devoted to course content and teaching methods with a view to

the development of improved techniques. Arrangements might be made for these younger teachers to observe and study the methods of their more experienced colleagues; and their own methods might, in turn, be observed and criticized in an organized program of practice teaching. When possible, this procedure might be accompanied by concurrent and related study in a neighboring university having versatile and inspiring teachers of English whose courses could be pursued and whose methods could be observed. Such a plan, requiring a lightening of teaching schedules during the period of the experiment, would entail an increased budget allotment for English.

If this plan could be given a trial under the general supervision of a central agency, such as a committee of the Society for the Promotion of Engineering Education, it could be coördinated and observed systematically and the results made known from time to time as the work progressed.

A second possibility is the selection of some one institution, or possibly even two or three, which would establish, for a trial period and with financial aid, centers for the training and development of a carefully selected group of younger teachers from other institutions under the leadership and the instruction of a member or members of the staff of the host institution. Fortunately there are institutions which have the prime requisites of this plan—a single man, or a staff, with the capacity and the qualities of leadership needed for its success. This plan, also, might be undertaken under some form of general sponsorship so that it could be looked upon as the undertaking of the fraternity of engineering education at large, with the advantages of general interest which would thus accrue to it.

Conclusion

In concluding this report our committee would affirm as a basic conception of work in English, whether for engineers or for other groups, that the portion of the experience of the individual in his effort to achieve requisite ability in the art of expression which is encompassed by the period of study in college, is but one part—a very important one, it is true—of his total program of development. And it should be so considered and evaluated. The college portion of this program begins at a level determined by home and community backgrounds and by previous schooling. Starting from this level it leads the student to some more or less advanced stage of his development. If it is properly conceived and executed, it relates that stage to his immediate future and to his more remote future as well, to the vocational field he will enter, and to the position in society at large that he will achieve, neglecting no one

of these aims at the expense of the others. Of basic importance, his period of college training in English should motivate him to continued study and development, not only in the arts of written and oral expression but also in other fields of cultural interest that are related to the study and use of the mother tongue. He should be given such a view of all that is preserved in the writings of our greatest creative minds that he will have the incentive to explore them for himself and thus to enrich his entire life. Of all the members of the faculty of the engineering school, it is the teacher of English who has the unique opportunity thus to direct the student toward this phase of his future development. It is also, without doubt, his greatest responsibility.

MECHANICAL ENGINEERING PAGE

Those who personally dominate are heroes for the hour; those who build men are immortals.

R. L. SWEIGERT, Georgia School of Technology, *Editor*

A REPORT OF THE 1940 ANNUAL MEETING

By

THE HEAT POWER AND MECHANICAL LABORATORY COMMITTEES

At the Pennsylvania State College meeting in June 1939, the Heat Power and Mechanical Laboratory Divisions voted to hold joint programs at the next annual meeting. This meeting will be held at the University of California in June 1940. It was decided to contact Professor L. M. K. Boelter, of the University of California, and ask his help in preparing a program. Professor Boelter replied with many suggestions for the program, and the committee is developing the program along the lines suggested by him.

The lines of development are indicated below:

1. Process Steam Generation Problems.
   Most of our work in power plants deals with central station design. The large field of industrial power and in particular, power and process steam uses, is seldom discussed in our classes. The committee is asking a man from the oil refineries and a man from the public utilities to prepare papers on "Basic Factors for Teaching Power Plant Design for Oil Refineries."
2. Surveys of Heat Power Courses.
   This problem is being approached from two points of view: that of the Heat Power work in our colleges and the work on Heat Power in the semi-professional Junior Colleges. Two papers are being prepared on these topics.
3. Air Conditioning Instruction.
   Two papers are being prepared on this topic, one giving the views of industry, and one describing the work being done on this subject at the University of California.
4. Heat Transfer Instruction.
   Two papers are being prepared on this subject, one dealing with the work done in Heat Power courses and another discussing this problem from the Agricultural Engineering requirements.
5. Heat Power Laboratory Methods.
   A paper is being developed discussing the use of "unit operation apparatus" in the laboratories. A second paper deals with "Thermodynamic Experiments" in the laboratory.

The above program is still in the process of development. The committee would welcome suggestions as to its improvement. We would like to encourage

discussions of these topics at the meeting. Anyone desiring to prepare a formal discussion on these topics is requested to so advise the committee.

Frank D. Carvin, Chairman,
Heat Power Division,
Newark College of Engineering.

Joseph E. Lambertine, Chairman,
Mechanical Laboratory Division,
Brooklyn Polytechnic Institute.

Editor's Note: One of the functions of the page is to disseminate information on pertinent items in the program, so that criticism and suggestions may come from the membership in order to make the programs as interesting and as productive of ideas as possible. Give your suggestions and ideas to the Committees and aid in the improvement of Mechanical Engineering Education.

THE T-SQUARE PAGE

DEVOTED TO THE INTERESTS OF THE
DIVISION OF ENGINEERING DRAWING

A. W. LEIGHTON, *Editor*, Tufts College

TENTATIVE PROGRAM FOR DIVISION AT BERKELEY

CONFERENCE SESSION: Monday, June 24, 2:00 P.M. CLAIR V. MANN, *Chairman*, presiding.

(*a*) Committee Report and panel discussion; "Engineering Drawing Instruments used by Students," H. M. McCully, Chairman, and other members of the Committee.

(*b*) Committee Report and panel discussion; "Office and Laboratory Equipment, and Housing Facilities of the Effective Engineering Drawing Department," Justus Rising and J. N. Arnold, Purdue University; H. H. Jordan, University of Illinois, and speaker, to be announced.

(*c*) Paper and Panel Discussion; "The Junior College in Relation to the Teaching of Engineering Drawing," B. M. Green, Stanford University; F. M. Warner, University of Washington, H. B. Langille, University of California.

(*d*) Paper and Discussion: "Stereoscopic Methods in Engineering Drawing and Descriptive Geometry," J. T. Rule, Massachusetts Institute of Technology; Justus Rising, Purdue University.

DINNER MEETING: Monday, June 24, 6:30 P.M. CLAIR V. MANN, *Chairman*, Presiding:

(*a*) Address: Speaker to be announced.

(*b*) Report of the Committee on Annual Drawing Competition.

NOONDAY LUNCHEON: Thursday, June 27, Twelve Noon. Divisional Business Meeting.

Thursday, June 27, 4:00 P.M. Meeting of Executive Committee of Drawing Division.

CHICAGO CONFERENCE ON DRAWING

This conference was held jointly under the auspices of the Executive Committee of the Drawing Division and Armour Institute of Technology, with the coöperation of Lewis Institute, on February 17, last. Five members of the Executive Committee, including the chairman and the secretary, and sixteen past officers of the Division, were among those participating. Two items which came from this conference are of interest to all members of the Division:

(1) It was definitely decided to hold an annual drawing conference, such as the Chicago one, in the Chicago-Detroit metropolitan district in January or February of each year. This conference is to be open to college teachers of engineering drawing, practicing engineers, and teachers of drawing in high schools and vocational schools.

(2) There was a serious consideration of the making of a comprehensive national study of instruction in mechanical and engineering drawing in whatever area the same may be taught—high schools, colleges, or in industry. The need of a research fund of some $2,500 was again brought up. Suggestion was made that it may be possible to interest the Federal Office of Education in such a study, perhaps to the extent of coöperating with a selected group from the Division of Engineering Drawing. This group would be responsible for preparation of a comprehensive syllabus, showing the detailed subject matter which should be included as minimum content in engineering curricula, and should also indicate for what engineering technical subjects the engineering drawing courses should be made absolutely prerequisite. The thought was that perhaps the United States Office of Education would already have collected comprehensive information relating to the teaching of drawing in the high schools, and might also be willing to publish the results of the study in a comprehensive bulletin. The Division officers expressed the viewpoint that the Division would not enter on any such study unless, and until, approved by the parent Society, but were desirous that Chairman Mann should take the initiative and in some way learn, if possible, if the Federal agency would care to coöperate in any such study.

LETTER TO THE EDITOR

ECOLE POLYTECHNIQUE

Montreal, March 16, 1940.

F. L. Bishop, Ph.D., Esq.,
Secretary of the Society for the
Promotion of Engineering Education,
University of Pittsburgh,
Pittsburgh, Pa.

My dear Dr. Bishop:

Your suggestion to publish a notice in the Journal of Engineering Education, advising of our desire to get in touch with Professors and Engineers who can lecture in French, is excellent.

You undoubtedly know that the Ecole Polytechnique is the Faculty of Engineering of the Université de Montréal. The near totality of its students are French Canadians and all teaching is done in French. However, the Engineering activities of our Graduates follow very closely the usual Canadian and American Engineering practice, and we use mostly English and American text-books and sources of reference in the applied subjects of our Course.

As I indicated in my first letter, we wish to supplement our regular Course in General Engineering by a series of extra curricular lectures to the Undergraduates and Graduates, principally in the subjects of Strength of Materials, Applied Mechanics and Structures, Mining and Electricity.

We could probably arrange the programme of lectures in such a way as to bring little disturbance to the usual activities of the Lecturers, if it is found necessary to do so.

The Lecturers would have to be men with a well established reputation in their chosen field.

I am grateful for your assistance in this matter. If you feel that more information would be preferable for the notice that you offer to publish in the Journal, I will be glad to enlarge upon the above. Personally I think that the best procedure would be for those whose interest might be aroused to communicate with me for further details.

Sincerely yours,

ARMAND CIRCÉ,
Dean

AMERICAN ASSOCIATION OF JUNIOR COLLEGES

Enrollment in junior colleges in the United States has doubled in the last seven years, according to the 1940 Junior College Directory, just issued by the American Association of Junior Colleges.

Enrollment has increased from 155,588 to 196,510 in the last year. This 41,122 increase, which is 26.4 per cent, is the greatest ever reported, according to Walter C. Eells, secretary of the association. There are now 575 junior colleges, as compared with 556 reported a year ago.

Stating that "a whole series of social changes have thrown responsibilities on the educational system never anticipated until they were fairly upon us," and that "they all converge on that age group in the population with which the junior colleges are concerned," Dr. George F. Zook, president of the American Council on Education, told convention delegates of the American Association of Junior Colleges, in Columbia, Mo., March 1, that they must meet an educational challenge. He suggested that:

1. Junior colleges should conceive of their field of effort as including the educational needs of the entire youth population, particularly those 18 and 19 years of age. Once such a philosophy is accepted the present traditional curriculum leading on to the completion of an A.B. degree will become only a small part of the total program—though a very important one. Alongside it and far exceeding it in numbers will be terminal curricula in various vocations, including home-making, and in general education as a preparation for social life and the realization of one's own peculiar interests and abilities.

2. Such junior colleges supported from public funds should be integrally connected with the secondary school system so as to represent a natural extension of secondary education.

3. Coöperative programs of part-time education and part-time work should be extensively organized with local industries and commercial establishments on the one hand, and with public agencies, including the National Youth Administration, on the other.

4. Each state should provide for a system of junior colleges, each of which would be attached to a local cosmopolitan high school. Such a system should be supported in part by the state, in part by the local school district, in part by tuitions for non-resident students paid by the student's home district and in part by student fees.

5. Junior colleges whether publicly or privately controlled should become cultural leaders on a broad front in the communities in which they are located. The junior college should for example offer facilities for the

development of musical talent and arrange for musical concerts. It should assist in bringing provocative speakers to the city. It should organize a program of classes, public forums, and discussion groups for adults in the afternoon and evening. It should stimulate the formation of clubs for the study of literature and art. It should assist in making wholesome recreation facilities available.

6. Study your own problems in the light of the national situation. I rejoice with you that a comprehensive exploration of the junior college situation is about to get under way. I hope that it is only the fore-runner of a longer period of intense self examination. This exploratory study from national headquarters should be accompanied by a specifically organized local study in each and every junior college.

7. And finally, I am pleading for more junior college faculty members who are not only competent in some chosen field of subject matter but who are also intelligent about their students, about American education and about the complex social life which presumably they are preparing young people to enter. If the junior colleges rise to the challenges now confronting them it will be because their faculties are equal to the occasion.

The youth problem is as wide as the interests of young people and as deep as their feelings. It includes an opportunity for employment, for recreation, for a home and for self development. All agencies of government and social welfare have been summoned to make their respective contributions to the solution. Education bears one of the heaviest responsibilities. It must arrange to accommodate all types of young people, to offer them the kind of programs which will be helpful to them respectively, to integrate their classroom work with employment and to make good citizens out of them. To what other division of the educational system does this responsibility fall more naturally and certainly than to the junior colleges?

NECROLOGY

EMBERT HIRAM SPRAGUE died March 9, 1940, as the result of a heart attack. A graduate of Dartmouth College in 1900, Professor Sprague, who was born in Haverhill, Mass., December 20, 1875, followed an active career in engineering, including mining, railroad, and erection work in South Africa until his appointment at the University. A member of the faculty of the College of Technology of the University of Maine since 1915, Professor Sprague was appointed to a full professorship in 1920, later becoming head of the department, and in 1934 became professor of sanitary engineering. He had been in ill health for several years.

Professor Sprague was a member of the Society for Promotion of Engineering Education, American Society of Civil Engineers, the Maine Association of Engineers, Phi Kappa Phi, general scholastic society, Tau Beta Pi, engineering honor society, and the New England Planning Conference. As an active member of the Orono community, he was treasurer of the Universalist Church, a member of the Orono Chamber of Commerce, and the Orono Fire Committee.

While a faculty member at the University, Professor Sprague was greatly interested in student activities and served on many committees such as the athletic board of which he was a member for fifteen years, and continued as an honorary member, and on instructional committees such as the Technology Committee on Graduate Study. He was coordinator of the technology research lecture program and chairman and sponsor of the student chapter of the American Association of Civil Engineers.

On graduation from Dartmouth, Sprague entered the employ of the New England Telephone and Telegraph Company, and later became draftsman for the American Bridge Company, and then the Riter-Conley Company, bridge builders. He worked for the Central South African Railroad until 1904, when he worked for a construction company in Johannesburg. He then turned to mining and worked as surveyor and assayer for gold and diamond mines in South Africa. In 1909 Professor Sprague returned to the United States and became an engineer with street construction companies in New York City. He was employed by the Maine State Highway Commission as a bridge inspector in 1915 until his appointment to the University faculty.

NEW MEMBERS

ADAMS, HENRY C., Assistant Professor of Naval Architecture, University of Michigan, Ann Arbor, Mich. H. E. Keeler, A. H. White.

BAIER, LOUIS A., Associate Professor of Marine Engineering, University of Michigan, Ann Arbor, Mich. H. E. Keeler, A. H. White.

BERNHARD, RUDOLF K., Professor and Head, Dept. of Engineering Mechanics, The Pennsylvania State College, State College, Pa. H. P. Hammond, F. L. Bishop.

BRAGG, EDWARD M., Professor of Naval Architecture and Marine Engineering, University of Michigan, Ann Arbor, Mich. Re-admission.

BUNKEN, JOHN W. M., Professor of Biology, Massachusetts Institute of Technology, Cambridge, Mass. K. T. Compton, J. R. Killian.

CALHOON, FLOYD N., Assistant Professor of Mechanical Engineering, University of Michigan, Ann Arbor, Mich. H. E. Keeler, R. C. Porter.

CAMP, CHESTER C., Professor of Mathematics, University of Nebraska, Lincoln, Nebr. J. W. Haney, O. J. Ferguson.

CANNON, JOSEPH H., Professor of Electrical Engineering, University of Michigan, Ann Arbor, Mich. Re-admission.

DAKE, EARL D., Professor of Civil Engineering, South Dakota School of Mines, Rapid City, S. D. J. O. Kammerman, C. G. Watson.

DAVIDSON, ARTHUR J., Instructor in Civil Engineering, University of Idaho, Moscow, Idaho. J. E. Buchanan, R. H. Hull.

DAVIS, HUGH J., Instructor in Civil Engineering, Southern Methodist University, Dallas, Texas. R. D. Landon, Sophus Thompson.

DECKER, FLOYD A., Assistant Professor of Engineering, Texas College of M. & M., El Paso, Texas. H. E. Degler, B. R. Short.

DIETZ, ALBERT G., Instructor in Building Engineering and Construction, Massachusetts Institute of Technology, Cambridge, Mass. Dean Peabody, W. C. Voss.

DOBSON, WILSON J., Instructor in Engineering Mechanics, University of Nebraska, Lincoln, Nebr. J. P. Colbert, T. T. Aakhus.

FRANKFORTER, CLARENCE J., Associate Professor of Chemistry and Chemical Engineering, University of Nebraska, Lincoln, Nebr. O. J. Ferguson, J. W. Haney.

GREEN, ROY C., Instructor in Electrical Engineering, Texas A. & M. College, College Station, Texas. H. C. Dillingham, C. F. Goodheart.

HAMMOND, THOMAS M., Instructor in Engineering and Physics, Schreiner Institute, Kerrville, Texas. H. C. Dillingham, J. A. Focht.

HANEY, PAUL D., Instructor in Sanitary Engineering and Chemistry, University of Kansas, Lawrence, Kans. I. C. Crawford, Earnest Boyce.

HANSEN, HOLGER M., Assistant Professor of Engineering Mechanics, University of Michigan, Ann Arbor, Mich. C. T. Olmsted, J. Ormondroyd.

HAWLEY, RANSOM S., Professor of Mechanical Engineering, University of Michigan, Ann Arbor, Mich. H. E. Keeler, A. D. Moore.

HOLLAND, LEWIS N., Assistant Professor of Electrical Engineering, University of Michigan, Ann Arbor, Mich. H. E. Keeler, A. D. Moore.

HOLLISTER, VERNON L., Professor of Electrical Engineering, University of Nebraska, Nebr. J. W. Haney, O. J. Ferguson.

HOLME, THOMAS T., Instructor in Mechanical Engineering, Lehigh University, Bethlehem, Pa. F. V. Larkin, A. W. Luce.

INGALLS, JAMES W., Associate Professor of Industrial Research, Norwich University, Northfield, Vt. F. L. Bishop, Nell McKenry.

JOHNSON, C. DAVID, Assistant Professor of Physics, Northeastern University, Boston, Mass. C. F. Muckenhoupt, A. S. Knowles.

KEITH, HENRY H. W., Professor of Naval Architecture, Massachusetts Institute of Technology, Cambridge, Mass. K. T. Compton, J. W. Haney.

KELSO, LESLIE E. A., Assistant Professor of Electrical Engineering, University of Wisconsin, Madison, Wis. K. F. Wendt, Ed. Bennett.

KOHLER, HENRY L., Assistant Professor of Mechanical Engineering, University of Michigan, Ann Arbor, Mich. H. E. Keeler, A. H. White.

KURZWEIL, ARTHUR C., Instructor in Engineering, Marin Union Junior College, Kentfield, Calif. Re-admission.

LIDDICOAT, RICHARD T., Assistant Professor of Engineering Mechanics, University of Michigan, Ann Arbor, Mich. R. A. Dodge, C. T. Olmsted.

LIUM, ELDER L., Associate Professor of Civil Engineering, University of North Dakota, Grand Forks, N. D. L. C. Harrington, W. E. Bridge.

LOUTHAM, M. RICHARDS, Professor of Mathematics, Bluefield Junior College, Bluefield, Va. C. E. Trent, J. B. Jones.

LOWERY, ARTHUR, Teaching Scholar in Economics, The Ohio State University, Columbus, Ohio. H. W. Bibber, E. E. Dreese.

MARMO, E. JOSEPH, Assistant Professor of Engineering Mechanics, University of Nebraska, Lincoln, Nebr. T. T. Aakhus, O. J. Ferguson.

MCCOY, JAMES E., Head, Dept. of Chemistry, Bluefield Junior College, Bluefield, Va. C. E. Trent, E. B. Norris.

METCALFE, HENRY M., Instructor in Civil Engineering, University of Idaho. Moscow, Idaho. J. E. Buchanan, R. H. Hull.

MICKEY, CLARK E., Chairman, Dept. of Civil Engineering, University of Nebraska, Lincoln, Nebr. Re-admission.

MIDDENDORF, HENRY Q., Assistant Professor of German, Polytechnic Institute of Brooklyn, Brooklyn, N. Y. L. F. Rader, H. R. Codwise.

MURRAY, RAY M., Instructor in Mechanical Engineering, The Rice Institute, Houston, Texas. J. H. Pound, C. R. Wischmeyer.

NICKELSEN, JOHN M., Associate Professor of Mechanical Engineering, University of Michigan, Ann Arbor, Mich. H. E. Keeler, R. C. Porter.

NOBLE, GILBERT W., Associate Professor of Petroleum Engineering, Missouri School of Mines & Metallurgy, Rolla, Mo. H. H. Armsby, I. H. Lovett.

PRESCOTT, SAMUEL C., Dean of Science, Massachusetts Institute of Technology, Cambridge, Mass. K. T. Compton, J. W. Haney.

PUGSLEY, JOHN B., Director, School of Administration, Northeastern University, Boston, Mass. W. C. White, W. E. Nightingale.

REEKS, MARK R., Instructor in Machine Design, Stevens Institute of Technology, Hoboken, N. J. W. R. Halliday, E. D. Furman.

ROSE, LISLE A., Professor and Head, Dept. of Languages, Michigan College of M. & T., Houghton, Mich. G. W. Swenson, M. H. Manderfield.

RULE, JOHN T., Associate Professor of Engineering Drawing and Descriptive Geometry, Massachusetts Institute of Technology, Cambridge, Mass. A. L. Goodrich, R. D. Douglass.

RUNGE, LULU L., Assistant Professor of Mathematics, University of Nebraska, Lincoln, Nebr. J. W. Haney, O. J. Ferguson.

SCHNEIDEWIND, RICHARD, Associate Professor of Chemical and Metallurgical Engineering, University of Michigan, Ann Arbor, Mich. A. H. White, E. R. Shorey.

SCHRAMM, E. FRANK, Chairman, Dept. of Geology, University of Nebraska, Lincoln, Nebr. J. W. Haney, O. J. Ferguson.

SMITH, CHAUNCEY W., Professor of Agricultural Engineering, University of Nebraska, Lincoln, Nebr. O. J. Ferguson, J. W. Haney.

STALEY, HOWARD R., Assistant Professor of Building Engineering and Construction, Massachusetts Institute of Technology, Cambridge, Mass. K. T. Compton, W. C. Voss.

STIEFEL, KARL J., Instructor in Electrical Engineering, Worcester Polytechnic Institute, Worcester, Mass. T. H. Morgan, V. Siegfried.

THEOBALD, JOHN J., Assistant Professor of Civil Engineering, College of the City of New York, New York City. Fred. Kuhlen, S. J. Tracy.

TURNER, CLAIRE E., Professor of Biology and Public Health, Massachusetts Institute of Technology, Cambridge, Mass. K. T. Compton, J. R. Killian.

VINCENT, EDWARD T., Professor of Mechanical Engineering, University of Michigan, Ann Arbor, Mich. H. E. Keeler, R. C. Porter.

WATSON, HARRY J., Assistant Professor of Mechanical Engineering, University of Michigan, Ann Arbor, Mich. H. E. Keeler, R. C. Porter.

WEISS, JOSEPH R., Instructor in Mechanical Engineering, College of the City of New York, New York City. S. J. Tracy, Frederick Kuhlen.

WHIPPLE, WILLIAM, Professor of Steam Engineering, Louisiana State University, University, La. L. J. Lassalle, Hamilton Johnson.

WILSON, LEE C., Instructor in English, Rhode Island State College. Kingston, R. I. W. B. Hall, R. L. Wales.

313 new individual members + 4 new institutional members.

COLLEGE NOTES

Armour Institute of Technology will conduct a three-term Summer Graduate Institute, June 17–July 13; July 15–August 10; August 12–September 7.

The faculty of the Summer Institute for 1940 includes, in addition to prominent men from the staff of Armour Institute, the following visiting professors: Ralph M. Barnes, Iowa State University; John R. Baylis, City of Chicago; Barnett F. Dodge, Yale University; William R. Everitt, Ohio State University; C. C. Furnas, Yale University; E. Hurwitz, Chicago Sanitary District; Lydik S. Jacobsen, Stanford University; G. B. Karelitz, Columbia University; Gabriel Kron, General Electric Company; Charles O. Mackey, Cornell University; Floyd W. Mohlman, Chicago Sanitary District; J. C. Morrell, Universal Oil Products; H. C. Taylor, Western Electric Company; Stephen P. Timoshenko, Stanford University; Frank C. Vilbrandt, Virginia Polytechnic Institute; and John I. Yellott, Stevens Institute of Technology.

The faculty members of Armour Institute who will coöperate in this summer program include: Paul L. Copeland, Lloyd H. Donnell, H. P. Dutton, Rolf Eliassen, Lester R. Ford, L. E. Grinter, Vasili I. Komarewsky, Max Jacob, Harry MacCormack, Joseph Marin, Myril B. Reed, Hans Reissner, Max Sadowsky.

This Summer Institute is divided into seven separate and distinct divisions and the program of specialized classes have been arranged to provide an opportunity for graduate work on the highest possible plane. These divisions include, Advanced Mechanics, Chemical Engineering and Chemistry, Civil and Sanitary Engineering, Electrical Engineering and Physics, Mechanical Engineering, Industrial Engineering and Applied Mathematics.

In making the announcement, it was pointed out by Institute Officials that the typical Summer Graduate course will meet for the equivalent of two hours lecture daily, including Saturdays for four weeks. The student would be permitted to carry only one course for credit during each period of four weeks, making possible, in a short period of intensive study and continuous attention to one subject, a very rapid development of knowledge of the subject. Such courses, it was pointed out, would be credited toward advanced degrees.

Clemson College.—The college enrollment is at an all time high, about five percent above that of last year. The increase in

the upper classes is considerably larger than in the freshman group. Added barracks accommodations for one hundred fifty were occupied this fall.

Numerous changes have taken place in the engineering faculty personnel. J. A. Stevenson, formerly Assistant Professor of Civil Engineering, on leave of absence the past two years, has resigned to accept employment as engineer for the Agricultural Adjustment Administration. His work for this year is being taken by L. A. Perry, on leave from the South Carolina State Highway Department, who was graduated from Civil Engineering at Clemson in 1937. A. M. Quattlebaum, who has filled the position the past two years, is working toward a doctorate at the University of Iowa. H. W. Dougherty has been added to the Civil Engineering staff as instructor. Graduated from the University of Tennessee in 1936 and granted the M.S. degree in 1938, both in Civil Engineering, Mr. Dougherty has been in the employ of the Tennessee Valley Authority in construction. J. T. Massey who was instructor in Electrical Engineering resigned to accept a faculty appointment and to do graduate work at North Carolina State College. H. E. Slone, Assistant Professor of Electrical Engineering the past two years, resigned to go into teaching in a technical high school in Binghamton, New York. W. D. Stevenson, Jr. and E. B. Therkelsen have been employed as instructors in Electrical Engineering to fill the vacancies left by these two men. Mr. Stevenson was graduated from Princeton University in 1934 and from Carnegie Institute of Technology in 1939 with B.S. in Electrical Engineering from each. Mr. Therkelsen was graduated from the Montana State College in 1936, the Massachusetts Institute of Technology in 1939, and has nearly completed the work for the Master of Science degree at the latter institution. Both men have had experience in practical work. R. M. Geer, a graduate of Clemson in the Architectural class of 1939, has been added to the Architectural Department as Graduate Assistant.

The B. A. Behrend Research Laboratory equipment—a group of special metal working machines with tools, gages, and attachments, valued at about $75,000—has been established in a special laboratory in the Engineering Shops Building. An extra mechanic has been employed in the Shops Department so that the regular mechanician will have time to devote to the care of the equipment.

The student-hour load of the Engineering College is the largest it has ever been due to the fact that the increase in enrollment in the last several years has made the upper classes, which are now getting into engineering work proper, larger than previously. In certain departments work has to be carried on in extra time as the facilities are fully used during the regular teaching day. A sub-

stantial increase made this year in the funds for the College Library has afforded much-needed increase in the Engineering Library book and periodical lists.

University of Detroit.—Mr. Ralph R. Johnson, in charge of Coordination, reports that 80 per cent of the upper class students eligible for coöperative employment were employed during the first semester of the current school year.

During the year 1939 two new instructors were added to the faculty of the Engineering School, namely, Lawrence Lentz, and Paul C. Hoffman. Mr. Lentz has been engaged as instructor in mechanical engineering. He holds a master's degree from the University of Michigan and completed the graduate training course for engineers of the Chrysler Corporation. He has had important engineering experience both with the Chrysler Corporation, and more recently, with the E. R. Little Co., consulting mechanical engineers of Detroit. Mr. Hoffman has been engaged as instructor in engineering drawing. He is a graduate in mechanical engineering of Marquette University and served for a time as engineer in the office of the Marquette University Superintendent of Buildings. In this capacity he designed and supervised the installation of heating and ventilating equipment for the new buildings in that institution. Since then he has been designer for a machinery manufacturing corporation of Chicago.

During the same year Ralph W. Tapy, Assistant Professor of Electrical Engineering, resigned from the faculty to assume the position of Professor of Electrical Engineering at the University of New Mexico. Professor Tapy has been replaced temporarily by Mr. Edward J. Abfalter who obtained leave of absence from the Detroit Edison Co. in order to fill the position left vacant by the departure of Professor Tapy. Mr. Abfalter is a graduate of the University of Detroit and has been with the Detroit Edison Co. for the past 12 years in the operating division. Previous to this he was Service Manager for the Walbert Mfg. Co. of Chicago.

Mr. Jasper Gerardi, Assistant Professor of Engineering Drawing, has been appointed acting head of the drawing department. Professor Gerardi graduated from the University of Detroit with the degree of Bachelor of Civil Engineering in 1929. He joined the faculty of the Engineering College in that year and was appointed to the Department of Engineering Drawing. He had previously been a student assistant in the Department of Drawing. In 1935, he was granted the degree of Master of Science by the University of Michigan. Students in his classes have been particularly successful in the annual competitions in drawing and descriptive geometry conducted by the Society for the Promotion of

Engineering Education. Professor Gerardi has held positions with the Detroit Edison Co., Mason L. Brown Civil Engineers, and the Wood Construction Co., and is a member of the Society for the Promotion of Engineering Education, the Engineering Society of Detroit, and an Associate Member of the American Society of Civil Engineers.

The enrollment of the Engineering College of the University of Detroit reached a total of 783 students for the semester beginning in September 1939.

Georgia School of Technology.—A new development is taking place in the Southeast. At present there are very few places in the South where adequate graduate work can be taken by those who are qualified for such work. It has been necessary for such students to go to some other section of the country in most cases. A notable example of this condition arose when a young lady desiring to study Georgia social problems had to go to a Northern University where she studied Georgia problems under a native Georgian, who has an international reputation in the Social Sciences.

To eliminate such situations a University Center is in the process of developing in the Atlanta area. The University Center will include the Georgia School of Technology, Emory University, Agness Scott College, the University of Georgia, Columbia Seminary and the Atlanta Art Association. The best points of each school are to be correlated, each school developing along the lines best suited for it with duplication of effort eliminated.

$3,000,000 has already been pledged for the University Center, and a campaign to raise an additional $2,000,000 is underway. A gift of $2,500,000 has been promised by the General Education Board, making a total of $7,500,000 for the initial development of the center.

The place of the Georgia School of Technology in the University Center will be to develop graduate work of the highest character in engineering and the scientific fields that are basic to engineering.

When the development reaches a mature stage, the Southeast will have one of the finest graduate centers in the country.

Professor Harry Dexter Watson has just been made head of the department of Mechanical Engineering at the **University of Maine**, succeeding the late Professor William Jordan Sweetser whose sudden death occurred October 16, 1939. Professor Watson, who holds both bachelor and master's degrees from the University, has been associated with the Mechanical Engineering staff here since 1920. For several years past, in addition to University duties, he has been engaged in consulting, installation and sales work in heating and air conditioning.

SECTIONS AND BRANCHES

The eighth annual meeting of the **Pacific Southwest Section** was held at the University of Nevada, Reno, Nevada, on December 28, 29, 30, 1939. The attendance, totalling forty-six, plus thirteen ladies, represented thirteen colleges and two junior colleges. The Section was especially fortunate in having as its honor guest and speaker at the annual dinner Dean O. J. Ferguson of the University of Nebraska, President of the Society.

The first afternoon session was opened with an address of welcome by Leon W. Hartman, President of the University of Nevada, and it is in order to remark that the terms of his warm greeting were enthusiastically fulfilled by all members of the local committees and other faculty members with whom we came in contact. The convention, occupying two and a half days, was organized into three morning and two afternoon sessions at which the following papers were read and discussed:

What are the Aptitudes Required in Engineering? F. H. Cherry, University of California.

Selection and Guidance of Students. G. L. Sullivan, University of Santa Clara.

Trends in American Education, Primary and Secondary. F. W. Traner, Dean, School of Education, University of Nevada.

Notes from the New Psychology. J. N. Pettit, Graduate Student, Stanford University.

The Accrediting Program from the Viewpoint of the Colleges Being Accredited. T. C. Adams, University of Utah.

The Rise of Trade Unionism as it Affects the Training of Young Engineers.

In the Motion Picture Industry. W. G. Angermann, University of Southern California.

Experience in the San Francisco Bay Area. H. B. Langille, University of California.

Present Status of Instruction in Surveying. J. C. Park, University of Arizona. (Read by B. M. Green.)

Plans for the Annual Convention at University of California in 1940. B. M. Woods, University of California.

An informal luncheon was held each day at the Hotel Golden, an informal dinner on the 28th at the El Cortez Hotel, and the an-

nual dinner at the same hotel on the evening of the 29th, at which President Ferguson spoke on Society affairs.

On Saturday afternoon, after the close of the formal meetings, there was a most interesting automobile trip to Virginia City, Carson City and other points of historical interest.

At the business meeting, held during the afternoon session on the 29th, the following officers and committee members for 1940 were unanimously elected:

Chairman: P. S. BIEGLER, University of Southern California.
Vice-Chairman: H. H. WHEATON, Fresno State College.
Secretary-Treasurer: B. M. GREEN, Stanford University.
Executive Committee: E. C. FLYNN, University of Santa Clara; E. D. HOWE, University of California; W. E. MASON, University of California at Los Angeles; F. H. SIBLEY, University of Nevada, retiring chairman.

It was voted to hold the 1940 meeting at the University of Southern California with the date left to the consideration of the Executive Committee.

The ladies reported that they were delightfully occupied with a full program of their own arranged by a local committee headed by Mrs. F. H. Sibley.

BOYNTON M. GREEN,
Secretary-Treasurer

BOOK REVIEWS

Alternating Current Circuits. BRYANT, CORRELL AND JOHNSON. McGraw-Hill Book Co., Inc. 3d Edition. 522 pages. Price $4.50.

In the third edition of "Alternating Current Circuits" the authors have divided the text material into 16 chapters. The first 7 chapters deal with the theory and development of equations for single phase alternating current circuits. The next 4 chapters take up polyphase circuits, chapter 10 deals with unbalanced circuits by means of symmetrical phase components. Chapter 12 to 15 inclusive deals with the study of transmission lines. The last chapter treats the study of nonsinusoidal wave forms by the use of Fourier's series.

The text material is amply illustrated by 110 examples and 480 problems.

The material is very logically presented and the derivation of equations is very thorough and clear.

The text is primarily intended for study by Junior students in Electrical Engineering.

PHILIP E. RUSH

Fabre and Mathematics and Other Essays. LAO GENEVRA SIMONS. Scripta Mathematica, New York. 101 pages. Price, one dollar.

This small volume contains four essays: Fabre and Mathematics, The Interest of Alexander von Humboldt in Mathematics, The Influence of French Mathematicians at the End of the Eighteenth Century, and Short Stories in Colonial Geometry. Three of the essays have appeared previously, the one on Humboldt is new. The author quotes from the works of Jean Henri Fabre, "poet and prophet of the insect world," to demonstrate the penetrating mathematical insight developed by a man whose investigations were not carried beyond the calculus. Excerpts from the famous Cosmos are cited to show Humboldt's interest in the history of numeration and his appreciation of the "irresistible charm in the contemplation of mathematical truths." The last two essays have titles which are self-explanatory.

The value of the book is summarized in the author's preface. "It is believed that interest in all these matters exists among teachers, scientists and laymen who delve below the surface in the writings of men in other fields than their own or who are concerned with the survival of subject matter in their own field."

GEORGE W. PETRIE

Industrial Surveys and Reports. WALTER RAUTENSTRAUCH. x, 185 pp. John Wiley & Sons, N. Y. 1940. Price $2.50.

Report writing can be approached from either of two points of view; either that which considers the report as an English composition, or that which regards it as a compilation of data for the convenient use of its reader. Just as we can see more distinctly with two eyes than with one, any really good report needs to take due account of both of these angles, and Professor Rautenstrauch adopts this view in his treatment of the topic.

The first chapter deals with the elements of a good report; statement of its subject, order of presentation, selection of facts and illustrative data, logic, style, and mechanical make-up. These are treated briefly, since it is assumed the reader has had at least some preparation in previous instruction in English composition. The second chapter develops in detail, under the heading "The Nature of Industrial Surveys and Reports for Financing Purposes," the more important aspects of some of these general considerations. Next the form of the report is elaborated, followed by a discussion of a survey of the business in general, of the company's position in the industry, its business and financial policies, and its organization and personnel.

Chapter VI deals with patents and good will, labor conditions, sales policies and methods, and is followed by a chapter on the physical equipment. The concluding chapter deals with the analysis of financial statements, conclusions, and recommendations. The appendices include a typical report, instructions on the preparation of charts for engineering reports (taken from the Code of Preferred Practice for Graphic Presentation Time Series Charts of the A. S. A., sponsored by the A. S. M. E.), tables and formulae most frequently used in financial calculations, a summary of the formulae used in estimating the economic characteristics of a business enterprise, and a brief but adequate bibliography of other works on report writing and related topics.

It will be seen that the author does not attempt to cover the writing of every kind of report on all conceivable topics, but narrows his treatment to reports on the business aspects of industries. This was done deliberately, in the belief that a better comprehension of how to approach an individual problem in report-writing can be thus obtained, rather than from a more superficial treatment of a broader field. It seems probable that this is true, and at any rate it is an excellent presentation of how to write reports from which bankers may judge the worth of enterprises for which their support may be solicited.

Since the work was written for use as a text-book in engineering schools it includes a judicious selection of problems for solution

by the student and is, in general, well adapted for that purpose. It deserves commendation from this aspect as well.

T. T. R.

Advanced Algebra. S. BARNARD AND J. M. CHILD. Macmillan and Co., Limited, St. Martin's Street, London, 1939.

As the authors say in their preface to this volume, it is a continuation of their "Higher Algebra" and is intended for the mathematical specialist. The opening chapter deals with Cross Ratio and Involution. Although these are topics that are usually found in texts on Geometry rather than algebra, they make an excellent transition from the authors' treatise on "Higher Algebra." The sections on Elimination, Invariants, Covariants, and Canonical Forms follow naturally the full account of the Theory of Equations given in the "Higher Algebra." In these sections, as throughout the book, there are illustrative examples that are straightforward applications of the theory and many problems that suggest further study and research.

There are chapters discussing the Complex Variable, Exponential and Logarithmic Functions, Probability, and Continued Fractions. In keeping with the plan of the book, the exposition is on a high plane.

The chapter on Linear Transformations includes formation of Covariants, the Hessian, Covariants of the Cubic and Quartic, and Canonical Forms.

The authors close with a discussion of Homographic Transformations. The theory in this chapter is illustrated by both examples and figures. The Miscellaneous Exercises, which contain 121 problems, afford the student a fine opportunity to test his command of the theory presented in the text.

The book is very well written and will make a valuable addition to the advanced student's collection of worth while books.

JOHN C. KNIPP

Automatic Design of Continuous Frames in Steel and Reinforced Concrete. L. E. GRINTER. The Macmillan Company. New York, 1939. 141 pages. Price $3.00.

In this little book the author has presented a distinct contribution to structural design. The outstanding feature of this work is that the author has attacked directly the problem of design—keeping in mind that design and not analysis is the more important procedure.

There have been remarkable advances in recent years in the methods of structural analysis. It is thought that the procedure of automatic design will lead to similar advances in design methods.

One might describe this book by saying that it does to some extent for design what the Cross method does for analysis. The methods of automatic design are similar to the moment distribution method in that section moduli are balanced instead of moment. The advantages of such a procedure are obvious in that much work is eliminated in analyzing assumed structures and then redesigning the overstressed and understressed members, and also, in that the most economical structure is arrived at directly.

The methods are extended to include design for live loads and design with haunched members.

This text should make important changes in the study of both analysis and design.

M. L. RUTTER

Ripper's Heat Engines. New Edition. Revised by A. T. J. KERSEY. Longmans, Green and Co. 337 pages. $1.60.

A very pleasant feature of this book is the easy manner of explaining fundamental principles by illustrations of simple laboratory apparatus. Once the principle is illustrated a smooth transition is made to the application in an actual machine or other piece of engineering equipment.

This clarity of illustration is particularly noticeable in the properties of water and steam and their application to evaporating and condensing equipment.

In content the book includes a section on internal combustion engines in addition to the major items of a steam plant. The equipment featured is naturally of British design.

The stated purpose of the revision was to put proper emphasis on equipment in relation to its present day use and in general to bring the subject matter up to date.

There is no doubt of the value of this book as an introductory text.

G. O. MANIFOLD

A History of the Growth of the Steam Engine. Centennial Edition. By ROBERT H. THURSTON with a supplementary chapter by WILLIAM N. BARNARD. Cornell University Press. 555 pages. $3.00.

This work has been made a very highly interesting history by the use of extracted passages from old records. In the light of subsequent developments many of the statements made during the time of experimentation are amusing; others are remarkably prophetic.

After reading this volume one cannot help again resolving to count to at least five hundred before saying that a proposal is

impossible or even impractical, however absurd it seems at the moment.

A number of biographical sketches are included, all of which add to the pleasure of reading the book. One of particular interest is that of James Watt.

The total period covered by this record extends from 200 B.C. to 1939 A.D. and steam equipment from Hero's turbine to those of the present day is covered in some detail.

This record is one that could hardly fail to prove entertaining and instructive to anyone, and doubly so to an engineer.

G. O. MANIFOLD

Writing the Technical Report. J. RALEIGH NELSON. McGraw-Hill Book Company, New York. 1940. xv, 373 pp. $2.50.

It has now been nearly thirty years since Professor Earle of Tufts issued the first textbook in technical writing. His monumental work, still used as reference in many engineering schools, was at once the announcement of a new method of teaching writing to engineers and also the fulfilling of the need for an adequate text. Organization and more organization were its keynotes in both precept and example. But nothing was said about the engineering report as a distinct form of writing. Two years later, W. O. Sypherd of Delaware issued his own text, which omitted many things, but included a section on the writing of engineering reports. Thus was born the ancestor of many chapters and ultimately whole texts devoted to technical report writing.

The first of the whole books on technical reports was that of Ray Palmer Baker of Rensselaer. It was published in 1924, almost exactly the halfway point between Professor Earle's text and the present time. Dr. Baker's book not only dignified engineering reports to the point of needing a whole text and a whole course, but also presented reports as an ancient form of writing, often used but seldom analyzed or taught.

Since Baker's text, engineering reports have received full volumes from such authors as Gaum and Graves, of Pennsylvania State; Prescott, of M. I. T. (published privately and later revised by Crosby and Bartlett); Agg and Foster of Iowa State; and Howell of North Carolina, who recently prepared a lengthy revision of Baker.

The newest arrival is the text of J. Raleigh Nelson, "Writing the Technical Report." As have most of the others, this book grows out of the experiences of many years in the classroom with engineering students. Professor Nelson at Michigan University is one of those fortunates who have a separate department of English for the school of engineering. In that way he has a species of

contact not obtainable where all English students are thrown together. He is a member of the engineering faculty as much as the teacher of hydraulics or alternating currents. He also has the advantage of location in a state heavily industralized and in a university closely responsive to the industrial needs of the state.

Professor Nelson's text emphasizes organization above everything else, with discussions, illustrations, and even graphs driving the point again and again. His book is especially good in the richness of material from which it may draw for illustrations of every problem of proportion and presentation. Whole sections of the book are composed of model reports, complete with title page, table of contents, and bodily structure. Teachers of technical writing will welcome this material for its ability to answer questions often raised in expensive class time.

Even the discussion of paragraph structure, usually regarded as fundamental material, is here subordinated to the general theme of organization-of-the-whole. Elementary grammatical material is practically eliminated, being relegated to a few pages in one of the "clinics" under the section on criticism. Such matters as hyphenation, abbreviation, and numbers are much less adequately treated than in former texts.

Quite new and welcome is the selection on criticism of the report, a section that will probably be used more by instructors than by students. However, the mere fact that the material is included in the text lays on the student the burden of correcting most of his faults before his paper reaches the instructor. It is one more of the many qualities the book has for the elimination of lost motion in the student's writing.

It is unfortunate that this excellent book is destined for such narrow use in the classroom. Many engineering schools have courses in technical writing, but few can devote a whole term to reports alone. The book will therefore be on reference shelves more than on student desks.

A work so good must have faults, but even some of them are attractive. The writer is so full of his topic that he descends to reminiscences and personalities, especially in the front and back of the book. The opening paragraphs of his "Preface" and "Acknowledgments" recount memories and situations known to those doing similar work, and not cared for by others; and the inclusion of a final "Retrospect" smacks more of a college annual than of an impersonal text. The writer's personal view is evident in the chapter on "The English of the Report" when he devotes several paragraphs to a condemnation of poor English training in high schools.

Likewise, the author's single eye for organization allows to pass into the text many trite and fuzzy lumps of jargonese he probably would never accept in a student paper. Such spineless indefinities as "case," "field," "line," "proposition," and the like occur constantly, while the more objectionable "as to" is everywhere, even in sectional titles. Other invertebrates are "with reference to," "with regard to," "ultimately terminate," "line of direction," and "so far as . . . is concerned." The author even succumbs to that third-personal engineer's nightmare, the dangling participle.

Another weakness is the poor wording of the definitions in Chapter I. The one allotted to exposition might just as accurately be applied to description or any of the others, even narration, which is surely an "orderly setting forth of ideas." The real definition of exposition, the explanation of generalities, as opposed to description, the explanation of particularities, is buried in the middle of a paragraph in the middle of a page somewhere in Chapter V.

The discussional portions of the book suffer from infrequent division and omission of subheads, violations of the very rules so aptly illustrated in the model reports.

But its good qualities far outweigh its bad. One definition, that of a report "as a thing to be designed to meet certain definite requirements like any structure destined to carry its load," is the happiest dictum of the whole book and would justify reading many chapters.

A. M. FOUNTAIN

The Construction of Roads and Pavements. 5th Edition. THOMAS R. AGG. McGraw-Hill Book Co. 483 pages. Price $4.00.

This book presents a much needed revision of a standard work in the field of highway engineering.

The section on the organization of governmental agencies for road building has been brought up-to-date to conform with the organizations now used by various branches of the government.

References throughout the text have been revised to include modern works on the various subjects under discussion. The exception to this is the chapter on highway grades where old values for constants as well as old references are used.

The chapters on soil, particularly Chapter IV, constitute a good presentation of soil theory and practice. This is one of the most complete elementary discussions of soil as a road material that I have seen. The references in this section are especially complete and supplement the text.

As usual, Dean Agg excels in his presentation of the economic phases of highway construction and financing.

I believe that this edition has been weakened by the omission of the standard tests on highway materials as they were presented in the previous edition. This omission makes it impossible to use the book as a text for a complete highway course without the addition of a laboratory manual.

In general, the revisions have improved the text and will make it possible to use the book without supplementing it with up-to-date material.

F. BROMILOW

NECROLOGY

Henry E. Publow was born in Detroit January 4, 1892, and graduated from Michigan State College in 1914. He received the professional degree of Chemical Engineer in 1919, and Metallurgical Engineer in 1927. He was a member of Alpha Chi Sigma, Beta Kappa, Sigma Xi, and Tau Beta Pi fraternities. He was Assistant Engineer with A. Bentley & Sons in 1914, Instructor in Chemistry M.S.C. 1915–18, Assistant Professor M.S.C. 1918–25, Associate Professor of Chemistry M.S.C. 1925–30, Associate Professor of Chemical Engineering M.S.C. 1930–36, Professor of Chemical Engineering M.S.C. 1936–date. He was also President of Toledo Wire and Iron, Inc. 1934–date. He was an author of numerous bulletins on the microstructure of low carbon steel and a member of the following professional societies: American Society of Steel Treaters, American Chemical Society, S.P.E.E., American Society of Metals, and Michigan Engineering Society.

We feel Professor Publow's loss keenly as he was an outstanding teacher and a splendid administrator.